THE

MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY & TRADE

1892

Copper Matte and Bars in 1892.

NUMBER OF SAMPLES ASSAYED BY US:

1889—**2,747** 1890—**3,345** 1891—**4,111** 1892—**4,265**

TONS SAMPLED:

1889—**35,000** 1890—**36,800** 1891—**56,300** 1892—**58,200**

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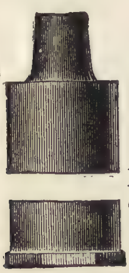

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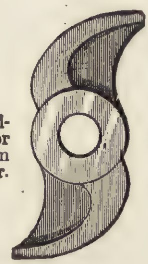

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From the Earliest Times to the end of

1892

VOL. I.

REVISED, SEPTEMBER, 1893.

EDITED BY

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NEW YORK:
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1893.

PREFACE.

This volume is a result of the development of the annual statistical numbers of the *Engineering and Mining Journal*, and owes its existence to the appreciation with which these statistics have been received by business men, by experts, and by others interested in the mineral industry throughout the world.

The modern newspaper has made promptness in furnishing information not only familiar but indispensable to the man of affairs, and accurate and timely statistics have now become absolutely necessary for the intelligent direction of industry, trade, and legislation. The collection of such statistics in an industry which extends over the face of the entire globe is, however, a work so vast and difficult that it has hitherto been considered impossible except through the unlimited resources of governments; and as the machinery of government is not adapted to the rapid attainment of results, the statistics of the mineral industry have been so tardily collected and published in all countries that their value has been greatly impaired.

For many years the *Engineering and Mining Journal*, as the leading representative of this great industry, has accumulated vast stores of statistical information relating to it, and has greatly improved the machinery for the collection of statistics. In 1874, 1875, and 1876 it published the first complete statistics of the coal production of the United States; in 1889, as special Government agent for the census, the editor of the *Journal* collected the statistics of gold and silver in the United States, and for a number of years past the statistics of copper, lead, spelter, etc., have been collected for each calendar year, and, with much other information on the general subject, have been published early in the following January in the *Engineering and Mining Journal.* On account of their accuracy and timeliness these statistics have come to be accepted with the greatest favor by the metal trades and by statisticians in every part of the world, as is shown on another page of this book, where are printed "The Opinions of the World on the Mineral Statistics published by the *Engineering and Mining Journal.*"

This universal appreciation of the work called for its extension, and conse-

quently in this initial volume there are given, for the first time, the statistics of substantially all the minerals and metals produced in the United States and in many other countries for the full year 1892, and often from the earliest times. This series of annual volumes it is intended shall, in due time, cover the entire mineral industry of the world, giving its statistics, its technology, and its trade, each succeeding volume not repeating the data given in previous issues, but supplementing them, and carrying forward the current history of the industry almost to the day of publication. Unaided by any governmental powers to enforce the making of returns, we have relied for success solely upon personal courtesy and confidence and upon the intelligent appreciation of the value of the work to the industry at large, and this great volume is the monument we have erected to the courtesy of those whose prompt and willing co-operation has alone rendered its success possible. Long experience in this kind of work has fully demonstrated the fact that men are in general more willing to give important and correct information to the private individual who can be held responsible for its proper use than to the more or less impersonal "government." It is indeed extremely rare that any producer neglects or refuses to give full, truthful, and satisfactory replies to our request for information.

Accuracy should always be the first care of the statistician, but it is scarcely less important to the business man that the information should be promptly furnished. Belated statistics are ancient history, of little practical value in the active affairs of an industry, or as a guide for legislation affecting it. The unrivaled facilities for accomplishing work of this kind which the *Engineering and Mining Journal* possesses in its large trained staff, its expert correspondents, and its means of getting information in every part of the world, enable it to secure both accuracy and promptness in a degree unattainable by ordinary government methods and machinery. In this as in so many other instances, work which private enterprise will undertake is usually better, and always more economically done than when performed by the government.

The volumes of the *Mineral Resources of the United States* issued by the United States Geological Survey have been drawn on as the only available source for most of the general statistics in the years 1880 to 1890, and the general chart for the year 1891 (the volume for that year is not yet issued) has also been consulted. Nevertheless many corrections have been made in those statistics, fuller information, and, as we believe, more reliable, being available to us.

The statistics collected each year by the *Engineering and Mining Journal*, having been again checked by the producers the following year, have been used as of the highest authority. The statistics for 1892 were exclusive, and those of 1891 for the most part were collected direct from producers for this work. No pains have been spared to render them in all respects full and trustworthy.

The statistics of the mineral industry in foreign countries in 1892 have also been collected specially for this work. For previous years the most authoritative official and non-official sources have courteously supplied the information, in some cases before its regular publication in the respective countries.

Foreign statistics have been given in but few cases in the publications of the United States Geological Survey; but inasmuch as no industry can be intelligently conducted and no legislation affecting it can be wisely enacted without a

knowledge of the conditions under which rival producers are working, much space has been given here to this important, though little understood, department.

Subjects which are uppermost in the business world naturally demand the greatest attention in this industrial work. Consequently the statistics and technology of gold and silver receive here very full attention. The excellent statistics of gold and silver production published by the United States Mint are used for foreign countries in recent years, and those of Soetbeer and other standard authorities for previous years. For the United States the figures given by the Mint have been adopted, except for 1889, when the fuller and more accurate census figures are quoted, and for the year 1892, when the statistics collected specially for this work have been used.

Much attention has been devoted to the subject of cost of production. The itemization of cost is the first essential step in securing economy in producing any article, and the history of every country and of every industry has shown that prosperity, whether national, industrial, or individual, is, in a general way, inversely proportional to the cost of supplying the rest of the world with what one produces. The great economies which command the markets for products are due, not to reductions in wages, but to increased knowledge and intelligence, and are accompanied by higher remuneration and a betterment of the condition of those engaged in the industry. It is well known that it is with the products of the highest-priced labor that this country is enabled to compete successfully in the markets of the world. It is with men paid on an average more than two dollars a day that the Atlantic Mine of Michigan earns dividends from an ore containing only $\frac{63}{100}$ of 1% of copper after mining it at great depth, crushing and concentrating it, smelting and delivering it in market fifteen hundred miles distant from the mine and paying every expense of general administration and improvements. It is with men earning on an average two dollars per day that a large colliery in this country puts its coal on the railroad, every expense—improvement, administration, etc.—included, at about forty-five cents per ton. It is the object of the *Engineering and Mining Journal* to give in detail, and of this supplemental volume of the *Journal* to summarize, the facts which show how such results are accomplished; to photograph, as it were, from time to time, the condition of the several departments of the mineral industry in various parts of the world, placing within the reach of all the information that intelligence can apply to the reduction of cost in producing and marketing the useful minerals and metals and in promoting the welfare of those engaged in this industry. In every country this information will enable those who legislate for and those who administer this industry to do so with an intelligent appreciation of the conditions affecting it in its every department, and, widely disseminated, will promote the national prosperity.

It is with the very greatest regret that we have been obliged in this work to use other than the metric system of weights and measures, which are now legalized in nearly every civilized country, and should be universally adopted. The necessity of conforming to custom and popular prejudice in a work so expensive as this explains the use here of that nightmare of weights and measures which, as a relic of barbarism, survives and is used in all English-speaking countries as "the English system." We have, however, where possible, reduced the number

of varieties of measures as used in the publications of the United States Government. All foreign statistics are given in this work in metric weights, and the United States products are given in the metric system as well as in the customary weights.

The advertising pages of this book will well repay the careful perusal and study of every reader who wishes to be well informed upon the present condition of the mineral industry. They give an admirable and practical insight into the present state of the mining and metallurgical arts, for in them nearly every manufacturer or dealer of note in this country advertises the machines, appliances, and processes which are now in vogue, or which it is sought to introduce, while the names and qualifications of the most eminent members of the engineering professions indicate the importance and directions of modern mining and metallurgy.

These advertising pages are no less important to those who desire a clear knowledge of the means by which this country has come to be far the most important producer of minerals and metals, than to him who wishes to know where to get that full and reliable information concerning the values of properties, machinery, processes, and products which should precede the investment of capital.

While as statisticians we have had to call attention to many defects in the *Mineral Resources* volume of the United States Geological Survey, we do not intend our criticisms to reflect personally upon the officers under whom the work has been conducted. Every one who has had experience in collecting statistics will recognize the difficulties attending such a vast work, and the absolute impossibility of a government-bureau doing it with a degree of accuracy satisfactory to either the statistician or to those who have to use the work, on so small an appropriation as has been allowed to the Division of Mineral Statistics of the Geological Survey. Dr. David T. Day, the Chief of this Division, has shown much ability, and has accomplished results which, considering the means at his command, are deserving of commendation. In many instances the personal popularity and influence of Dr. Day alone secured assistance in collecting statistics where the appropriation was insufficient to pay anything for the same, or at most to pay but a sum out of all proportion to the work involved. It was not possible under these conditions to do work which was satisfactory to its authors or to the public.

No one can appreciate more fully than the statistician himself the limits and shortcomings which are inseparable from all statistical work of this character. As further facts come to light and a higher degree of accuracy rewards our continuous efforts to render these volumes trustworthy, corrections will be made in the statistics should errors of importance be found. He is but a dishonest statistician who retains known important erroneous statements in order that the public, in its ignorance, may believe from the absence of corrections that his figures are accurate. Readers of this book are therefore earnestly requested to notify its editor of any errors or omissions which may be found in it, in order that corrections may be made in subsequent volumes, and suggestions which may render future volumes more valuable will be gratefully received.

RICHARD P. ROTHWELL.

NEW YORK, Feb., 1893.

CONTENTS.

PHOSPHATE ROCK.

PLATINUM GROUP OF METALS.

PLUMBAGO.

PRECIOUS STONES.

PYRITES.

QUICKSILVER.

SALT.

CONTRIBUTORS.

It would be impossible to enumerate here the names of all who have contributed statistics or other valuable information to this volume; we can only express our warm thanks and high appreciation of their courteous co-operation. It is proper, however, that those more directly connected with the getting out of the work should be mentioned individually, both that their services may thereby be better recognized and that the public may know the high standing and eminent qualifications possessed by those who have contributed to this statistical work. Another year it may be possible to make more extended notice, and to publish the portraits of the contributors to that volume. The following list is arranged in alphabetical order:

Adams, William H.—One of the most prominent and experienced mining engineers and metallurgists in America, who for many years past has devoted his attention chiefly to the pyrites, sulphuric acid, and phosphate industries. He prepared the articles on pyrites and sulphur. There is no one in this country more thoroughly conversant with these subjects.

Bailey, L. W., Ph.D., Geologist attached to the Geological Survey of Canada, and especially familiar with the geology and mineral industry of New Brunswick, collected the statistics of mineral production, and contributed much information concerning the industry of that Province.

Benedict, William de L.—A well-known mining engineer of extensive experience in various parts of the United States and Central and South America. Mr. Benedict has devoted special attention in his professional practice to tin mining and mines. He has examined all the tin districts of the United States, and has contributed many articles of importance to the technical periodicals. He was, therefore, especially well fitted to prepare the elaborate article on tin for this volume. Since the subject of the tin industry is attracting great attention on account of the legislation affecting it, much space has been devoted to it in this work.

Blandy, John F., Ex-Territorial Geologist, Prescott, Arizona, an engineer of wide experience in nearly every department of mining, and long a resident of Arizona, has contributed valuable information concerning the mines of that Territory.

Blue, Archibald, Director of the Bureau of Mines of Ontario, a very competent and devoted official, has kindly furnished the statistics of the mineral industry of Ontario.

Bullman, Charles, a mining engineer who has had much professional experience in various parts of South America, as well as in the United States, and has acted as mining expert to the most important consumers of platinum in this country, prepared the valuable article on the Platinum Group of Metals, in which he has incorporated many hitherto unpublished facts. He also contributed the article on South America. Mr. Bullman is the translator of the Mining Code of Colombia and has for some time past been attached to the editorial staff of the *Engineering and Mining Journal.*

Chatard, Thomas M., Ph.D., who has contributed a valuable article upon our natural soda deposits and industry, is one of the most prominent industrial chemists in this country. Dr. Chatard has long been known as one of the ablest scientists on the United States Geological Survey. He recently resigned from this, and is practicing in Washington as a chemical engineer in the investigation and industrial development of our chemical industry.

Chibas, Eduardo J., Mining and Civil Engineer of Cuba, having a special acquaintance with the mineral resources of Cuba, has contributed such information as the limited development of its mining industry affords.

Chism, Richard E., mining engineer of the city of Mexico and editor of *El Minero Mexicano,* contributed statistics and other information concerning the Mexican mineral industry.

Church, John A.—One of the most distinguished and experienced mining engineers in America. He was at one time on the editorial staff of the *Engineering and Mining Journal.* Prof. Church has examined mines in every part of this continent and in most of the foreign countries. For years he acted as mining engineer to Li Hung Chang, the celebrated Viceroy of the province of Chihli, China, opening and working mines in the northern provinces of

the empire. Prof. Church has made many valuable contributions to the literature of the profession of which he is so prominent a member.

Cramer, Stuart W., United States Assayer, Charlotte, N. C., who is thoroughly informed on the gold and silver mining industry in the South, contributed the statistics of that district and has furnished much valuable matter now published for the first time.

Delecroix, Émile, mining engineer and lawyer, and editor of the *Revue de Législation des Mines et Statistiques des Houillères en France et en Belgique*, contributes information concerning the French coal industry, with which he has long been identified.

Devenish, Robert J., civil engineer, has done good and careful work in collating information and checking statistical returns in this volume and in revising proofs as the work was passing through the press.

Dick, Archibald, mine inspector for British Columbia, with great politeness furnished statistics of the coal and gold production of that Province.

Donald, J. T., chemist and mining geologist, Professor of Chemistry, Bishop's College, Montreal, and a frequent contributor to scientific periodicals, furnished much information on the asbestos and mica industries of Canada.

Douglas, James, the eminent mining engineer and metallurgist, and President of the Copper Queen Consolidated Company, has shown great interest in the success of this work and has contribued much valuable information contained in its pages. Mr. Douglas's wide acquaintance with the copper mines and copper industry of the whole world has rendered his courteous cooperation on this work of exceptional value.

Eder, Henry, mining engineer, who had just returned from a visit, extending over two years, among the European mining and metallurgical works, furnished many notes upon the European mineral industry.

Emmens, Dr. Stephen H., a well-known chemist and metallurgist, who has contributed many valuable professional monographs to the technical periodicals of this country and England, has added to this volume an excellent summary of the known methods of treatment of zinc-lead sulphides, and also an article on the metallurgy of nickel.

Engelhardt, F. E., Ph.D.—This well-known chemist has long been specially identified with the salt industry in the official capacity of chemist to the salt works owned by the State of New York. No one in this country is more familiar with the industry or has done better work in connection with it. The valuable article on Salt which he contributes to this volume embodies full information on this important subject.

Gilpin, Edwin, for many years past Royal Inspector of Mines for Nova Scotia, and an accomplished and experienced mining engineer, has collected the statistics of mineral production in the Province of Nova Scotia, and has furnished much valuable information concerning its mineral industry. On this subject Mr. Gilpin is unquestionably the highest authority.

Hanauer, A., Jr., the proprietor of large lead-smelting works at Salt Lake, Utah, has contributed to this volume most of the statistics of Utah's mineral production—a subject with which no one else in the Territory is more familiar. Mr. Hanauer has displayed great interest in this work, and has spared no pains to collect full and reliable statistics for it.

Hofman, H. O., an experienced metallurgical engineer, Associate Professor of Mining and Metallurgy at the Massachusetts Institute of Technology, and the distinguished author of the admirable treatise on "The Metallurgy of Lead," recently published by the Scientific Publishing Company, contributes to this work the excellent monograph on Desilverization of Lead, which will be read with profit by every one interested in that department of the industry.

Holibaugh, J. R., of Joplin, Mo., who is extremely familiar with the zinc-lead industry of Missouri and Kansas, furnished much information which appears in the articles devoted to these metals in this volume.

Ingalls, Walter Renton, a well-known mining engineer, has had an extended professional experience in our Western mines and in Mexico. In 1890, 1891, and until early in 1892 he was assistant editor of the *Engineering and Mining Journal*, but early in 1892 he accepted

a professional engagement in Mexico, and on its expiration decided to make an extended visit to the European mining and metallurgical districts. He deferred this, however, in order to assist in collecting and editing the statistics for the present volume. His previous experience, both as an engineer and as an editor, fitted him in an especial manner for this work, in which he has given much valuable assistance.

Janin, Jr., Louis, a mining engineer, who for the past year has acted as assistant editor of the *Engineering and Mining Journal*, is an engineer and metallurgist of very wide and varied experience in many parts of the United States, Mexico, and South America, and has contributed numerous valuable technical monographs to the *Engineering and Mining Journal* and other engineering papers, and has also had much experience in the field of secular journalism. This double professional training has added materially to the value and efficiency of his work on this volume. The thorough monograph on the Cyanide Process for the Extraction of Gold and Silver which he contributes is by far the most complete, valuable, and authoritative treatise on this important subject which has yet appeared.

Jeans, J. S., the distinguished Secretary of the British Iron and Steel Institute, has contributed valuable information concerning the iron and steel industry in Great Britain.

Kemp, J. F., Professor of Geology at the School of Mines, Columbia College, and mining engineer, contributed to this volume, as to the annual statistical number of the *Engineering and Mining Journal* a year ago, articles on Antimony. Prof. Kemp has written an admirable treatise on "American Ore Deposits" which is now in course of publication by the Scientific Publishing Company.

Kent, William E., a distinguished mechanical engineer who has devoted much attention to the economical use of fuel, and is a frequent contributor to technical periodicals, has prepared the valuable monograph on the Heating Power of Coals for this volume, a contribution which will be found of great importance.

Keyser, William, President of the Baltimore Copper Smelting and Rolling Company, has with never-failing patience and courtesy furnished much information concerning the copper treated at his works and also concerning the cost of production at the Old Dominion mine in Arizona, one of the cheapest producers in this country.

Kunz, George Frederick, gem expert to Messrs. Tiffany & Co. of New York, and the well-known author of the magnificent work "Gems and Precious Stones of North America," published by the Scientific Publishing Company. Mr. Kunz is a frequent contributor to the technical and scientific periodicals, and was eminently well qualified to prepare the article on Precious Stones in this volume.

Langeloth, J., President of the American Metal Company, and Vice-President of the Balbach Smelting and Refining Company, has furnished very valuable information concerning the trade department of the mineral industry in which his company is so prominent a factor, and has, with unfailing courtesy and good-will, aided in many ways our efforts to secure full and reliable information.

Ledoux, Albert R., Ph.D., the distinguished chemist, whose works have sampled most of the copper matte which has gone to Europe in recent years and who has long been identified with the export copper trade, contributed the important article on American Methods of Ore Sampling and Assaying Copper, and has furnished much other information to this work, in the success of which he has taken great interest.

Leech, E. O., Director of the United States Mint, with unfailing courtesy placed at our disposition all the information possessed at the several branch mints and United States assay offices, and thus aided materially our work in collecting the statistics of the gold and silver production of this country.

Lewis & Sons, James, metal merchants, London and Liverpool.—The custom-house records of exports of copper matte, ore, etc., from the United States do not specify the amount of fine copper contained in the material shipped, while the British import returns do furnish this information. Messrs. James Lewis & Sons have given us much assistance in checking and supplementing the information obtained here, and in aiding our efforts to render reliable the figures given in this work.

LEWISOHN BROTHERS.—These well-known and enterprising metal merchants, who probably handle more copper than any other house in America, are especially well informed on everything connected with this department of the mineral industry. Mr. Leonard Lewisohn has courteously furnished much information, both as to the production of the many mines in which he is interested and as to the exports of copper and the gold and silver it contained.

LUNDBOHM, HJALMAR, mining engineer of Stockholm, Sweden, furnished interesting matter concerning the Swedish mineral industry.

LUNGE, GEORGE, PH. D., Professor of Technical Chemistry at the Federal Polytechnic School of Zurich, Switzerland.—This distinguished expert in the chemical industry, the well-known author of the great treatise on "The Manufacture of Sulphuric Acid and Alkali," has contributed to this volume, as he did a year ago, a review of the chemical industry in Europe, a subject on which there is no higher authority. Everything Dr. Lunge writes is perused with great interest.

McMEECHEN, THOMAS R., an experienced mining engineer of Denver, Colo., and who is also familiar with newspaper work, collected for this book valuable statistical information concerning the Colorado mineral industry, and furnished data used in the articles on special metals.

MERTON & CO., HENRY, London.—These well-known metal merchants have, with the utmost courtesy and enthusiasm, contributed very valuable data concerning foreign metal markets and foreign statistics of production, and in many other ways have facilitated our work.

OLCOTT, E. E., the distinguished mining engineer of New York, has furnished much information concerning the mines in several South American districts, with which his professional engagements have made him familiar.

ORIOL, ROMAN, mining engineer, Professor of Mining at the Royal School of Mines, Madrid, and editor of the *Revista Miniera* of Spain, has collected for this work the mineral statistics of Spain, as he did also a year ago, and has furnished the only report there is giving this information.

PENROSE, JR., R. A. F., PH.D.—This well-known mining engineer, who was attached to the Geological Survey of Arkansas and prepared the volume in that report on the ores of Manganese, contributed to this volume the article on Manganese, a subject on which he is the highest authority in this country.

PHILLIPS, WILLIAM B., PH.D.—A mining engineer and metallurgist of much experience and distinction, especially in the field of iron and steel metallurgy. He is well known through his professional writings, among which are his translation of Köhler's treatise on Faulting in Veins, published in the *Engineering and Mining Journal*, and his translation, jointly with Mr. E. Prochaska, of Wedding's work on "Basic Steel." Dr. Phillips was State Geologist of North Carolina, and Professor of Metallurgy in the Universities of North Carolina and Alabama, and is now assistant editor of the *Engineering and Mining Journal*. He has, in the subjects of coal, coke, iron, and steel, made a valuable contribution to this work.

PRATT, PROF. N. A., of Atlanta, Ga., the well-known chemist so long identified with the phosphate industry, has furnished information concerning production, shipments, etc.

ROTHWELL, JOHN E., mining engineer, who had charge of the Golden Reward Chlorination Works, Deadwood, S. D., and who has for years been one of our highest authorities on the chlorination of gold ores, contributes practical notes upon such a works. Mr. Rothwell's results at Deadwood are no doubt the best yet recorded in this department of metallurgy. His practical familiarity with every department of such a works adds to the value of his article.

SAHLIN, AXEL, a mining and mechanical engineer of wide and varied experience, whose experience with the mining and preparation of talc gave him exceptional information on this subject, prepared for this work the article on Talc.

SHIELDS, W. R., of Ohio, furnished valuable information concerning the bromine industry, with which he is prominently identified and on which he is undoubtedly the highest authority in this country.

SMITH, F. M., President of the Pacific Coast Borax Company, furnished interesting statistics and much valuable information concerning the borax industry.

Smith, Prof. William Allen, mining engineer, a graduate from the School of Mines, Columbia College, New York, and in 1892 lecturer on mining at the same college. He has had much experience in various departments of the mineral industry. During several years' residence and travel in Europe, where for a portion of the time he acted as private secretary to the Hon. George Bancroft, American Minister at Berlin, he became familiar with European methods, and has since maintained his interest and active participation in the industry in the United States, and has made valuable contributions to the literature of the same in the columns of the *Engineering and Mining Journal* and other periodicals.

Sonnemann, George A., mining engineer and metallurgist, who makes the application of electricity in mining his specialty, and has had experience in our Western mining districts, has devoted much time to this work in several departments. The special articles on electricity in mining prepared for this volume were crowded out, but will appear in the pages of the *Engineering and Mining Journal.*

Stanton, John, Secretary and Treasurer of the Atlantic, Central, and Allouez Copper Mining Companies, and whose admirable administration of their affairs and long experience in the copper trade have made him the highest authority, has shown great interest in the success of this work and has furnished valuable statistics for its use.

Stickney, Charles Wade, mining engineer and metallurgist, and whose experience with the bessemerizing of copper mattes at the Parrot Works, Butte, Mont., made him exceptionally familiar with the practical details of the process, contributes an important monograph on this subject. This article will be warmly welcomed by the profession.

Thompson, Robert M., President and General Manager of the Orford Copper Company, has shown the warmest interest in the success of this work, and has opened his books to us, affording the fullest information concerning the amount of material treated at his works and whence it came, and has promptly responded to the many calls we have made upon his courtesy and good-will. Mr. Thompson has also made in these pages a valuable contribution to the metallurgy of nickel.

Vivian & Sons, Swansea, Wales.—This well-known firm of metallurgists and metal merchants with great courtesy furnished valuable statistics of the British zinc industry.

Watteyne, Victor, a well-known Belgian mining engineer and statistician, contributed this year, as he has done in previous years, the article on the Belgian mineral industry, collecting many of the statistics specially for this work.

Wyatt, Francis, Ph.D.—This eminent chemist, the well-known author of the standard work "The Phosphates of America," published by the Scientific Publishing Company, contributed the valuable articles on the Chemical Industry and on Phosphates. Dr. Wyatt has long been recognized as one of the very highest authorities on all questions of industrial chemistry, and a late professional visit to Europe, where he spent several months, enabled him to give the most recent practice and invention in this rapidly changing industry. His articles give the very latest information on the subjects of which they treat.

Yates, H. N., chemist to the Cowles Electric Smelting and Aluminum Company, a thoroughly well-informed authority on all questions of the manufacture and uses of aluminum, contributed the article on that metal.

Mattoon, Charles F., a skillful and experienced reader, who has done and is doing very responsible work, has had charge of the important work of reading proof on this volume. The hurry incident to getting out such a book in so brief a period is not conducive to the best work; nevertheless it is believed that this work would be considered highly creditable even had abundant time been available for reading it.

That most important department of this volume, its business and financial administration, has been under the control of Mrs. Sophia Braeunlich, the very efficient business manager of the *Engineering and Mining Journal.* To her great business ability, experience, and taste are due the marked success of this work as a business enterprise and the handsome appearance of its advertising pages.

TABLES FOR CONVERTING UNITED STATES WEIGHTS AND MEASURES TO METRIC.

Linear.					Capacity.							
Inches to Millimeters.	Feet to Meters.	Yards to Meters.	Miles to Kilometers.		Drams to Cubic Centimeters.	Ounces to Milliliters.	Quarts to Liters.	Gallons to Liters.	Cubic Inches to Cubic Centimeters.	Cubic Feet to Cubic Meters.	Cubic Yards to Cubic Meters.	Bushels to Hectoliters.
25.4000	0.304801	0.914402	1.60935	= 1 =	3.70	29.57	0.94636	3.78544	16.387	0.02832	0.765	0.35242
50.8001	0.609601	1.828804	3.21869	= 2 =	7.39	59.15	1.89272	7.57088	32.774	0.05663	1.529	0.70485
76.2001	0.914402	2.743205	4.82804	= 3 =	11.09	88.72	2.83908	11.35632	49.161	0.08495	2.294	1.05727
101.6002	1.219202	3.657607	6.43739	= 4 =	14.79	118.30	3.78544	15.14176	65.549	0.11327	3.058	1.40969
127.0002	1.524003	4.572009	8.04674	= 5 =	18.48	147.87	4.73180	18.92720	81.936	0.14158	3.823	1.76211
152.4003	1.828804	5.486411	9.65608	= 6 =	22.18	177.44	5.67816	22.71264	98.323	0.16990	4.587	2.11454
177.8003	2.133604	6.400813	11.26543	= 7 =	25.88	207.02	6.62452	26.49808	114.710	0.19822	5.352	2.46696
203.2004	2.438405	7.315215	12.87478	= 8 =	29.57	236.59	7.57088	30.28352	131.097	0.22654	6.116	2.81938
228.6004	2.743205	8.229616	14.48412	= 9 =	33.28	266.16	8.51724	34.06896	147.484	0.25485	6.881	3.17181

Square.					Weight.			
Square Inches to Square Centimeters.	Square Feet to Square Decimeters.	Square Yards to Square Meters.	Acres to Hectaers.		Grains to Milligrams.	Avoirdupois Ounces to Grams.	Avoirdupois Pounds to Kilograms.	Troy Ounces to Grams.
6.452	9.290	0.836	0.4047	= 1 =	64.7989	28.3495	0.45359	31.10348
12.903	18.581	1.672	0.8094	= 2 =	129.5978	56.6991	0.90719	62.20696
19.355	27.871	2.508	1.2141	= 3 =	194.3968	85.0486	1.36078	93.31044
25.807	37.161	3.344	1.6187	= 4 =	259.1957	113.3981	1.81437	124.41392
32.258	46.452	4.181	2.0234	= 5 =	323.9946	141.7476	2.26796	155.51740
38.710	55.742	5.017	2.4281	= 6 =	388.7935	170.0972	2.72156	186.62089
45.161	65.032	5.853	2.8328	= 7 =	453.5924	198.4467	3.17515	217.72437
51.613	74.323	6.689	3.2375	= 8 =	518.3914	226.7962	3.62874	248.82785
58.065	83.613	7.525	3.6422	= 9 =	583.1903	255.1457	4.08233	279.93133

1 chain	=	20.1169	meters.
1 square mile	=	259	hectaers.
1 fathom	=	1.829	meters.
1 nautical mile	=	1853.27	meters.
1 foot=0.304801 meter,		9.4840158	log.
1 avoir. pound	=	453.5924277	gram.
15432.35639 grains	=	1	kilogram.

TABLES FOR CONVERTING METRIC TO UNITED STATES WEIGHTS AND MEASURES.

Linear.					Capacity.							
Meters to Inches.	Meters to Feet.	Meters to Yards.	Kilometers to Miles.		Milliliters or Cubic Centiliters to Fluid Drams.	Centiliters to Fluid Ounces.	Liters to Quarts.	Dekaliters to Gallons.	Hektoliters to Bushels.	Cubic Centimeters to Cubic Inches.	Cubic Meters to Cubic Feet.	Cubic Meters to Cubic Yards.
39.3700	3.28083	1.093611	0.62137	= 1 =	0.27	0.338	1.0567	2.6417	2.8375	0.0610	35.314	1.308
78.7400	6.56167	2.187222	1.24274	= 2 =	0.54	0.676	2.1134	5.2834	5.6750	0.1220	70.629	2.616
118.1100	9.84250	3.280833	1.86411	= 3 =	0.81	1.014	3.1700	7.9251	8.5125	0.1831	105.943	3.924
157.4800	13.12333	4.374444	2.48548	= 4 =	1.08	1.352	4.2267	10.5668	11.3500	0.2441	141.258	5.232
196.8500	16.40417	5.468056	3.10685	= 5 =	1.35	1.691	5.2834	13.2085	14.1875	0.3051	176.572	6.540
236.2200	19.68500	6.561667	3.72822	= 6 =	1.62	2.029	6.3401	15.8502	17.0250	0.3661	211.887	7.848
275.5900	22.96583	7.655278	4.34959	= 7 =	1.89	2.368	7.3968	18.4919	19.8625	0.4272	247.201	9.156
314.9600	26.24667	8.748889	4.97096	= 8 =	2.16	2.706	8.4534	21.1336	22.7000	0.4882	282.516	10.464
354.3300	29.52750	9.842500	5.59233	= 9 =	2.43	3.043	9.5101	23.7753	25.5375	0.5492	317.830	11.771

Square.					Weight.			
Square Centimeters to Square Inches.	Square Meters to Square Feet.	Square Meters to Square Yards.	Hectares to Acres.		Kilograms to Grains.	Hectograms to Ounces Avoirdupois.	Kilograms to Pounds Avoirdupois.	Grams to Ounces Troy.
0.1550	10.764	1.196	2.471	= 1 =	15432.36	3.5274	2.20462	0.03215
0.3100	21.528	2.392	4.942	= 2 =	30864.71	7.0548	4.40924	0.06430
0.4650	32.292	3.588	7.413	= 3 =	46297.07	10.5822	6.61386	0.09645
0.6200	43.055	4.784	9.884	= 4 =	61729.43	14.1096	8.81849	0.12860
0.7750	53.819	5.980	12.355	= 5 =	77161.78	17.6370	11.02311	0.16075
0.9350	64.583	7.176	14.826	= 6 =	92594.14	21.1644	13.22773	0.19290
1.0850	75.347	8.372	17.297	= 7 =	108026.49	24.6918	15.43235	0.22505
1.2400	86.111	9.568	19.768	= 8 =	123458.85	28.2192	17.63697	0.25721
1.3950	96.874	10.764	22.2	= 9 =	138891.21	31.7466	19.84159	0.28936

The only material standard of customary length authorized by the U. S. Government is the Troughton scale, whose length at 59°.62 Fahr. conforms to the British standard. The yard in use in the United States is therefore equal to the British yard.

The only authorized material standard of customary weight is the Troy pound of the Mint. It is of brass

of unknown density, and therefore not suitable for a standard of mass. It was derived from the British standard Troy pound of 1758 by direct comparison. The British avoirdupois pound was also derived from the latter, and contains 7000 grains Troy.

The grain Troy is therefore the same as the grain avoirdupois, and the pound avoirdupois in use in the United States is equal to the British pound avoirdupois.

The British gallon = 4.54346 liters.

The British bushel = 36.3477 liters.

By the concurrent action of the principal Governments of the world an International Bureau of Weights and Measures has been established near Paris. Under the direction of the International Committee, two ingots were cast of pure platinum-iridium in the proportion of 9 parts of the former to 1 of the latter metal. From one of these a certain number of kilograms were prepared, from the other a definite number of meter bars. These standards of weight and length were intercompared, without preference, and certain ones were selected as International prototype standards. The others were distributed by lot to the different Governments and are called National prototype standards.

The metric system was legalized in the United States in 1866.

The International Standard Meter is derived from the Mètre des Archives, and its length is defined by the distance between two lines at 0° Centigrade, on a platinum-iridium bar deposited at the International Bureau of Weights and Measures.

The International Standard Kilogram is a mass of platinum-iridium deposited at the same place, and its weight *in vacuo* is the same as that of the Kilogramme des Archives.

The liter is equal to a cubic decimeter of water, and it is measured by the quantity of distilled water which, at its maximum density, will counterpoise the standard kilogram in a vacuum, the volume of such a quantity of water being, as nearly as has been ascertained, equal to a cubic decimeter.

Long ton: 2240 lbs. avoirdupois	= 1016 kilo.	Barrel of petroleum = 42 gal. = 1.59 hec.
Short ton: 2000 " "	= 907.2 "	" " salt = 280 lbs. = 127 kilo.
Pound avoirdupois	= 453.6 grams.	" " lime = 200 " = 90.720 "
Flask of mercury = 76½ lbs. avoir.	= 34.700 kilo.	" " natural cement = 300 = 136.080 "
Troy ounce	= 31.104 grams.	" " Portland cement = 400 " = 181.440 "
Gallon	= 3.785 litres.	Gold coining value per oz. c. $20.6718 = $0.6646 per gram.
		Silver " " " " c. $1.9229 = $0.04157 " "

OFFICIAL UNITED STATES VALUES OF FOREIGN COINS, APRIL 1, 1894.

Country.	Standard.	Unit.	Value in U.S. Gold.	Coins.
			cts.	
Argentina	Both	Peso	96.5	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary	Gold	Crown	20.3	Gold: former system—4 florins ($1.929), 8 florins ($3.858), ducat ($2.287), and 4 ducats ($9.158). Silver: 1 and 2 florins. Present system—Gold: 20 crowns ($4.052) and 10 crowns ($2.026).
Belgium	Both	Franc	19.3	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	46.3	Silver: boliviano and divisions.
Brazil	Gold	Milreis	54.6	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
Canada	Gold	Dollar	100	
Central America: Costa Rica, Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	46.5	Silver: peso and divisions.
Chile	Both	Peso	91.2	Gold: escudo ($1.824), doubloon ($4.561), and condor ($9.123). Silver: peso and divisions.
China	Silver	Tael ‡	68.6 / 76.5	
Colombia	Silver	Peso	46.5	Gold: condor ($9 647) and double-condor. Silver: peso.
Cuba	Both	Peso	92.6	Gold: doubloon ($5.017). Silver: peso.
Denmark	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Ecuador	Silver	Sucre	46.5	Gold: condor ($9.647) and double-condor. Silver: sucre & divisions.
Egypt	Gold	Pound	494.3	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2, 5, 10, and 20 piasters.
Finland	Gold	Mark	19.3	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	Both	Franc	19.3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire	Gold	Mark	23.8	Gold: 5, 10, and 20 marks.
Great Britain	Gold	Pound	486.65	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Both	Drachma	19.3	Gold: 5, 10, 20, 50, and 100 drachmas. Silver: 5 drachmas.
Haiti	Both	Gourde	96.5	Silver: gourde.
India	Silver	Rupee	22.1	Gold: mohur ($7.105). Silver: rupee and divisions.
Italy	Both	Lira	19.3	Gold: 5, 10, 20, 50, and 100 lire. Silver: 5 lire.
Japan	Both*	Yen	99.7 / 50.1	Gold: 1, 2, 5, 10, and 20 yen. Silver: yen.
Liberia	Gold	Dollar	100	
Mexico	Silver	Dollar	50.5	Gold: dollar ($0.983), 2½, 5, 10, and 20 dollars. Silver: dollar (or peso) and divisions.
Netherlands	Both	Florin	40.2	Gold: 10 florins. Silver: ½, 1, and 2½ florins.
Newfoundland	Gold	Dollar	101.4	Gold: 2 dollars ($2.027).
Norway	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Peru	Silver	Sol	46.5	Silver: sol and divisions.
Portugal	Gold	Milreis	108	Gold: 1, 2, 5, and 10 milreis.
Russia	Silver	Ruble ‖	77.2 / 37.2	Gold: imperial ($7.718) and ½ imperial† ($3.86). Silver: ¼, ½, and 1 ruble.
Spain	Both	Peseta	19.3	Gold: 25 pesetas. Silver: 5 pesetas.
Sweden	Gold	Crown	26.8	Gold: 10 and 20 crowns.
Switzerland	Both	Franc	19.3	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
Tripoli	Silver	Mahbub §	41.9	
Turkey	Gold	Piaster	04.4	Gold: 25, 50, 100, 250, and 500 piasters.
Venezuela	Both	Bolivar	19.3	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

* Gold the nominal standard. Silver practically the standard. † Coined since January 1, 1886. Old half-imperial = $3.986. ‡ Shanghai and Haikwan (Customs). § Of 20 piasters. ‖ Silver the nominal standard. Paper the actual currency, the depreciation of which is measured by the gold standard.

INTRODUCTION.

THE MINERAL AND METAL PRODUCTION OF THE UNITED STATES.

The summary of the production of minerals and metals in the United States for the years 1880–88, both inclusive, which is given in the table accompanying this article, is that compiled by the Division of Mining Statistics of the United States Geological Survey. We have, however, rearranged the table, placing the various substances in alphabetical order to facilitate reference, added a column each year to give the equivalents in metric weights of the quantities which are expressed in the customary measures, and corrected important errors which our fuller information disclosed. An examination of this table, in which so many different kinds of weights and measures are used, is sufficient to convince any one of the barbarous nature of what we call our "system." Foreigners who now, with the exception of the English, universally use the metric measures, are unable to distinguish between our long and short tons, our barrels of 200, 280, 300, or 400 lbs., our pounds avoirdupois and our pounds Troy, our bushels of a dozen different weights, and our gallons of several incomprehensible kinds.

The figures for 1889 were collected by the Eleventh Census, with the exception of those for lime, cement, salt, zinc-white, borax, bromine, slate ground for pigment, and rutile, which were obtained, as usual, by the Division of Mining Statistics of the Geological Survey.

The *Engineering and Mining Journal* collected and published Jan. 2, 1892, the statistics of production of a certain number of the metals in 1891, but in collecting the full statistics for 1892 the output of many additional substances in 1891 was also ascertained. This has rendered it possible to make many corrections in the figures given by the Geological Survey chart for that year and to substitute the more accurate amounts. The volume of the *Mineral Resources* for the year 1891 has not yet been issued by the Geological Survey.

The statistics for the year 1892 are, of course, exclusively those collected by the *Engineering and Mining Journal.* They are in nearly all cases from direct returns by producers; but where it became necessary to estimate any portion of the output it was done by those actually engaged in the industry, whose familiarity with the local conditions and whose business relations enabled them to arrive, with substantial accuracy, at the output of unreported mines or works.

The State mine officials, whose duty it is to visit all the mines and to collect the statistics of production, etc., are in a better position than any one else to secure accurate returns. At our request they have taken much trouble to do this more carefully and promptly than usual. As a further check upon the accuracy

of the work many of the railroads have given statements of the coal originating on their several lines. In short, the greatest pains have been taken to make the statistics given in this volume accurate and trustworthy. It is not claimed that it is without errors,—no statistical work ever was or ever will be,—but should any corrections be found necessary, they will be made in the report for the current year 1893, which will be issued a year hence. In the mean time this is believed to be the most accurate statistical volume yet issued in this country.

The values given in these tables each year for the various mineral products are approximate only. We have included these columns for the years 1880–90, both years inclusive, because they are given in the Geological Survey table, and we have added statements of value for the years 1891 and 1892, compiled in the same manner, in order to conform to the statistics of the previous years. It should be said, however, that these estimates of values are frequently but little short of absurd. The values of the non-metallic substances represent their worth at the various points of production, which is clearly the proper manner for computation. The values of the metallic products, on the other hand, represent their worth in the principal markets, calculated on the basis of finished products, while, in the case of the non-metallic, the estimates are in most instances for the crude material; but in some cases, crude and refined are mixed in a heterogeneous manner. The value of silver, for example, is what it sells for in New York after it has been brought hither and refined, involving expenditures for carriage, insurance, refining, commissions, etc.; it is clearly ridiculous to add together figures for some substances which include such extraneous charges, with others which represent only the actual value of products at the mines or works.

The statistics of the production of non-metallic substances in this table are for the yield of American mines only. The statistics for the metals, on the other hand, give the output of the metallurgical works, but in some cases include the total from both foreign and domestic ores, and in other cases represent only the product of American mines. This is not indicated in the chart issued by the Geological Survey; and in order to prevent misunderstandings, which may easily arise from such confusion of methods, it is necessary to explain that the figures for aluminum, platinum, quicksilver, tin, and zinc represent domestic production only, as no ores of these metals are brought into the United States from foreign countries for reduction. The statistics for pig iron give the total make in the United States, including that derived from foreign ores. We have continued to prepare the figures for lead, copper, silver and gold in the same manner, specifying, however, the amount derived from foreign sources. Within the past two years large quantities of base bullion have been brought into the United States and refined in bond. It is to be remembered that a large part of the purely domestic copper is exported in the form of matte, or black copper, which are unfinished products. Large quantities of silver and gold are imported into the United States in ores and base bullion, which are refined by our metallurgical works. In the table the amount of the precious metals produced from ores of domestic origin is stated, and also the amount from foreign material. In the case of nickel, no ores were brought into the United States from foreign countries to be smelted here until 1889, when Canadian matte was first imported. The statistics for production here given state only the amount of metal reduced from ore produced by mines of the

United States, with the exception of the figures for 1889, which were collected by the Eleventh Census, and include 35,000 lbs. of nickel refined from Canadian matte.

The production of antimony in the United Seates was unimportant until the last few years, there being only a small amount smelted in San Francisco, all of which came from ores mined on the Pacific coast. In 1888 and 1890 some ore was mined in Arkansas and smelted in Philadelphia, but since the latter year no metal has been produced here, although a considerable amount of ore has been mined in Nevada and exported for reduction. Therefore, in order to make the figures for 1891 and 1892 comparable with those for the previous years, we have calculated the metal equivalent of the ore shipped, estimating its value at the mines before shipment and before smelting. In addition to this a certain amount of antimony produced and marketed in antimonial lead, as stated in the article on lead, is not included in the general table of mineral products.

The foregoing explanations and criticisms show how confusing is the chart of the "Mineral Products of the United States" published by the Geological Survey; and we reproduce it in the MINERAL INDUSTRY solely because it is a statistical authority to which frequent reference has been made in the past, and is in fact the only compilation of the mineral statistics for the years represented. We hope in the succeeding volumes of the MINERAL INDUSTRY to prepare a new chart, in which the statistics will be compiled in uniform manner and the elements of confusion which render that of the Geological Survey so misleading will be eliminated. For the present the reader is referred to the statistics given in the various articles in the following pages, where the manner of compilation and exactly what is represented are explicitly stated.

The production of the following minerals was not ascertained with satisfactory fullness and accuracy. We have therefore "estimated" it, in part or in some cases wholly, from the figures given in the *Mineral Resources* chart for 1891. While the figures given in this chart are evidently also estimated in many cases, and may be erroneous in some instances, they are here used as being already accepted, as they are the only reports available on the output of the following substances: Asbestos, building stone, corundum, feldspar, flint, grindstone, gypsum, infusorial earth, lime, millstones, mineral paints, mineral waters, potter's clay, and rutile.

The returns from the greater part of the granite quarries indicate a considerable decline in output during 1892, owing to strikes of the workmen, but other building-stone output increased in quantity. In the majority of the above substances the information we have received, though insufficient to base accurate estimates of production upon, indicates an increased output over 1891.

From these tables the enormous development of the mineral industry of the United States can be appreciated. This country is already in the first place as a producer of many of the minerals and metals; in pig-iron, steel, copper, gold, silver, petroleum, and several other things it stands first. In coal output we are rapidly moving forward to the leading position, having long ago distanced every country except the United Kingdom, and it is probable that within the next seven years we shall have overtaken that nation with an annual production for each approaching 200,000,000 metric tons. The coal production of the United States is now 81.08% of that of the United Kingdom, and is about 28.75% of the whole world's output.

MINERAL PRODUCTS OF

Calendar years

No.	Products.	Customary Measures.	1880.			1881.		
			Quantity.		Value at Place of Production	Quantity.		Value at Place of Production
			Customary Measures	Metric Tons.§		Customary Measures	Metric Tons.§	
	NON-METALLIC.							
1	Asbestos	Short tons†	150	136	$4,312	200	181.4	$7,000
2	Asphaltum	“ “	444	403	4,440	2,000	1,815	8,000
3	Barytes (crude)	Long tons‡	20,000	20,327	80,000	20,000	20,327	80,000
4	Borax	Pounds	3,860,748	1,751	289,870	4,045,405	1,835	303,365
5	Bromine	“	404,690	184	114,752	300,000	136	75,000
6	Building stone	....	....	....	18,356,055	....	....	20,000,000
7	Cement	Bbls.,300–400 lb.	2,072,943	....	1,852,707	2,500,000	....	2,000,000
8	Coal, anthracite	Long tons	23,449,742	23,832,768	38,680,250	28,512,516	28,978,237	64,152,000
9	Coal, bituminous *c*	“ “	42,307,400	42,998,445	59,123,340	50,279,840	51,101,101	62,849,000
10	Cobalt oxide	Pounds	7,251	3.2	....	8,280	3.3	....
11	Corundum	Short tons	1,044	947	29,280	500	454	80,000
12	Chrome ore	Long tons	2,288	2,325	27,808	2,000	2,033	30,000
13	Feldspar	“ “	12,500	12,704	60,000	14,000	14,228	70,000
14	Flint	“ “	20,000	20,376	80,000	25,000	25,408	100,000
15	Fluorspar	Short tons	4,000	3,629.7	16,000	4,000	3,629.7	16,000
16	Grindstones	....	....	....	500,000	....	....	500,000
17	Gypsum	Short tons	90,000	81,818	400,000	85,000	77,273	350,000
18	Infusorial earth	“ “	1,833	1,664	45,660	1,000	909	10,000
19	Lime	Bbls., 200 lbs.	28,000,000	2,545,454	19,000,000	30,000,000	2,727,272	20,000,000
20	Limestone for iron flux	Long tons	4,500,000	4,572,000	3,800,000	6,000,000	6,096,000	4,100,000
21	Manganese ore	“ “	5,761	5,855	86,415	4,895	4,974	73,425
22	Marls	Short tons.	1,000,000	907,441	500,000	1,000,000	907,441	500,000
23	Mica	Pounds	81,669	37	127,825	100,000	45	250,000
24	Millstones	....	....	....	200,000	....	....	150,000
25	Mineral paints	Long tons	3,604	3,662	135,840	6,000	6,097	100,000
26	Mineral waters	Gallons	2,000,000	....	500,000	3,700,000	....	700,000
27	Natural gas	....	*a*	....	....	*a*	....	....
28	Novaculite	Pounds	420,000	190.5	8,000	500,000	226.8	8,580
29	Ozokerite (refined)	“	*a*	....	....	*a*	....	....
30	Petroleum *j*	Bbls., 42 gals	26,286,123	3,678,202	24,183,233	27,661,238	3,869,936	25,448,339
31	Phosphate rock	Long tons	211,377	214,228.7	1,123,823	266,734	271,089.7	1,980,259
32	Plumbago	Pounds	....	....	*e* 49,800	400,000	181	30,000
33	Potters' clay	Long tons	25,783	26,204	200,457	25,000	25,408	200,000
34	Pyrites	“ “	2,000	2,032	5,000	10,000	10,163	60,000
35	Precious stones	....	....	....	100,000	....	....	110,000
36	Rutile	Pounds	100	*45.4	400	200	*90.8	700
37	Salt	Bbls., 280 lbs	5,961,060	757,944	4,829,566	6,200,000	793,285	4,200,000
38	Slate (for pigment)	Long tons	1,000	1,016	10,000	1,000	1,016	10,000
39	Soapstone	Short tons	8,441	7,657.8	66,665	7,000	6,352	75,000
40	Sulphur	“ “	600	543.5	21,000	600	543.5	21,000
41	Talc (fibrous)	“ “	4,210	3,729	54,730	5,000	4,537	60,000
42	Zinc-white	“ “	10,107	9,171.5	763,738	10,000	9,083	700,000
	Total value of non-metallic mineral products		....	....	$165,440,966	....	....	$209,477,668
	METALLIC.							
43	Aluminum, value at N. Y.	Pounds	*a*	....	....	*a*	....	....
44	Antimony, value at S Fran.	Short tons	50	45.3	$10,000	50	45.3	$10,000
45	Copper, value at N. Y. *h*	Pounds	60,480,000	27,441	11,491,200	71,680,000	32,523	12,175,600
46	Gold, coining value	Troy ounces	1,741,500	*54,165	36,000,000	1,676,300	*52,137	34,700,000
47	Pig-iron, value at N. Y.	Long tons	3,835,190	3,897,835	101,466,500	4,144,252	4,211,130	87,029,334
48	Lead, value at N. Y.	Short tons	97,825	88,770	9,782,500	117,085	106,248	11,240,160
49	Nickel, value at N. Y. *i*	Pounds	233,893	106.0	257,282	265,668	120.5	292,235
50	Platinum (crude)	Troy ounces	100	....	400	100	....	400
51	Quicksilver, value at S. F.	Flasks, 76½ lbs.	59,926	2,033.4	1,797,780	60,851	2,117.6	1,764,679
52	Silver, coining value	Troy ounces	30,320,000	*943,036	39,200,000	33,077,000	*1,028,787	43,000,000
53	Tin	Pounds	....	....	....	....	....	....
54	Zinc, value at N. Y.	“	23,239	21,088	2,277,432	26,800	24,319	2,680,000
	Total value of metallic mineral products		....	....	$201,283,094	....	....	$192,902,408
	Total value of non-metallic mineral products		....	....	165,440,966	....	....	209,477,668
	Estim. value of mineral products, unspecified *g*		....	....	6,000,000	....	....	6,500,000
	Grand total		....	....	$372,724,060	....	....	$408,880,076

* Kilograms.

† Short ton = 2000 lbs. ‡ Long ton = 2240 lbs. § Metric ton = 2204 lbs.

(*a*) Not reported.

(*b*) Including aluminum in alloys.

(*c*) Including brown coal and lignite.

(*e*) Value of crude product.

THE UNITED STATES.

1880 to 1892.

1882.			1883.			1884.			
Quantity.		Value at Place of Production	Quantity.		Value at Place of Production	Quantity.		Value at Place of Production	No.
Customary Measures.	Metric Tons.		Customary Measures.	Metric Tons.		Customary Measures.	Metric Tons.		
1,200	1,083.4	36,000	1,000	907	30,000	1,000	907	30,000	1
3,000	2,722	10,500	3,000	2,722	10,500	3,000	2,722	10,500	2
20,000	20,327	80,000	27,000	27,441	108,000	25,000	25,408	100,000	3
4,236,291	1,922	338,903	5,600,000	2,541	504,000	7,713,303	3,409	539,931	4
250,000	113	75,000	301,100	137	72,264	281,100	128	67,464	5
....	....	21,000,000	....	....	20,000,000	....	....	19,000,000	6
3,250,000	....	3,672,750	4,190,000	....	4,293,500	4,000,000	....	3,720,000	7
29,132,596	29,608,441	65,547,500	31,636,029	32,152,806	73,432,000	32,653,998	33,187,367	65,307,000	8
58,548,429	59,504,760	73,185,000	64,865,861	65,925,341	77,838,000	65,938,151	66,989,773	69,235,000	9
11,653	5.2	....	1,096	0.5	....	2,000	0.9	....	10
500	454	80,000	550	499	100,000	600	544	108,000	11
2,500	2,541	50,000	3,000	1,049	60,000	2,000	2,033	35,000	12
14,000	14,228	70,000	14,100	14,330	71,112	10,900	11,077	55,112	13
25,000	25,408	100,000	25,000	25,408	100,000	30,000	30,489	120,000	14
4,000	3,629.7	20,000	4,000	3,629.7	20,000	4,000	3,629.7	20,000	15
....	....	700,000	....	....	600,000	....	....	570,000	16
100,000	90,909	450,000	90,000	81,818	420,000	90,000	81,818	390,000	17
1,000	909	8,000	1,000	909	5,000	1,000	909	5,000	18
31,000,000	2,818,181	21,700,000	32,000,000	2,909,090	19,200,000	37,000,000	3,363,636	18,500,000	19
3,850,000	3,911,600	2,310,000	3,814,273	3,875,301	1,907,136	3,401,930	3,456,361	1,700,965	20
4,532	4,060	67,980	6,155	6,255	92,325	10,180	10,346	122,160	21
1,080,000	914,700.5	540,000	972,000	882,032.6	486,000	875,000	794,010.9	437,500	22
100,000	45	250,000	114,000	52	285,000	147,410	67	368,525	23
....	....	200,000	....	....	150,000	....	....	150,000	24
7,000	7,114	105,000	7,000	7,114	84,000	7,000	7,114	84,000	25
5,000,000	....	800,000	7,529,423	....	1,119,603	10,215,328	....	1,459,143	26
....	....	215,000	....	....	475,000	....	....	1,460,000	27
600,000	272.2	10,000	600,000	272.2	10,000	800,000	362.9	12,000	28
a	....	....	*a*	....	....	*a*	....	....	29
30,510,830	4,268,608	24,065,988	23,449,633	3,289,513	25,790,252	24,218,438	3,392,479	20,595,966	30
332,077	337,499.8	1,992,462	378,380	384,558.9	2,270,280	431,779	438,829.9	2,374,784	31
425,000	193	34,000	575,000	261	46,000	*a*	....	....	32
30,000	30,489	240,000	32,000	32,522	250,000	35,000	35,571	270,000	33
12,000	12,195	72,000	25,000	25,408	137,500	35,000	35,571	175,000	34
....	....	150,000	....	....	207,050	....	....	222,975	35
500	*227	1,800	550	*249.7	2,000	600	*272.4	2.000	36
6,412,373	820,448	4,320,140	6,192,231	791,794	4,251,042	6,514,937	833,583	4,197,734	37
2,000	2,032	24,000	2,000	2,032	....	....	2,032	2,000	38
6,000	5,435	90,000	8,000	7,259.5	150,000	10,000	9,074.4	200,000	39
600	543.5	21,000	1,000	908.3	27,000	500	454.2	12,000	40
6,000	5,444.6	75,000	6,000	5,444.6	75,000	10,000	9,074.4	110,000	41
10,000	9,083	700,000	12,000	10,899.0	840,000	13,000	11,797.3	910,000	42
....	....	223,408,023	....	....	235,519,564	....	....	212,697,759	
a	....	....	83		875	150	....	1,350	43
60	54.5	12,000	60	54.5	12,000	60	54.5	12,000	44
92,267,109	41,863	16,143,500	117,705,742	52,951	7,995,000	148,149,966	67,218	18,148,250	45
1,572,186	*48,899	32,500,000	1,451,249	*45,137	30,000,000	1,489,949	*46,341	30,800,000	46
4,623,232	4,698,822	106,336,429	4,595,510	4,666.495	91,910,200	4,097,869	4,164,786	73,761,624	47
132,890	120,590	12,624,550	143,957	130,632	12,322,719	139,897	126,948	10,537,042	48
281,616	128	309,777	58,800	26.7	52,920	64,550	29.3	48,412	49
200	....	600	200	....	600	150	....	450	50
52,732	1,833.0	1,487,042	46,725	1,626.0	1,253,632	31,913	1,110.5	936,327	51
36,197,695	*7,125,849	46,800,000	35,733,622	*1,111,415	46,200,000	37,744,605	*1,173,962	48,800,000	52
....	....	....	....	....	....	....	....	....	53
33,765	30,639	3,646,620	36,872	33,459	3,311,106	38,544	34,976	3,422,707	54
....	....	219,860,518	....	....	203,059,052	....	....	186,468,162	
....	....	223,408,023	....	....	235,519,564	....	....	212,697,759	
....	....	6,500,000	....	....	6,500,000	....	....	5,000,000	
....	....	449,768,541	....	....	438,578,616	....	....	404,165,921	

(*g*) Including fire-clay, common brick-clay, terra cotta, building sand, glass sand, limestone used as flux in lead-smelting, limestone used in glass-making, iron where used as flux in lead-smelting, tin ore, iridosmine, nitrate of soda, carbonate of soda, sulphate of soda, native alum, mineral soap, strontia, and pumice-stone.

(*h*) Including copper matte from imported pyrites, except in 1881, for which no returns are available for matte.

(*i*) Including nickel in copper-nickel alloy and in exported ore and matte.

(*j*) The production of petroleum stated in gallons is calculated in kiloliters, and converted to metric tons, by multiplying by 0.88. This, of course, gives a result only approximately correct, as the specific gravity of the various kinds of oil varies.

MINERAL PRODUCTS OF

Calendar years

No.	Products.	Customary Measures.	1885. Quantity. Customary Measures	1885. Quantity. Metric Tons.§	1885. Value at Place of Production	1886. Quantity. Customary Measures	1886. Quantity. Metric Tons.	1886. Value at Place of Production
	NON-METALLIC.							
1	Asbestos	Short tons†	300	272.2	$9,000	200	181.4	$6,000
2	Asphaltum	" "	3,000	2,722	10,500	3,500	3,176	14,000
3	Barytes (crude)	Long tons‡	15,000	15,245	75,000	10,000	10,163	50,000
4	Borax	Pounds	7,471,404	3,381	448,284	9,094,172	4,126	454,700
5	Bromine	"	320,000	145	92,800	428,334	194.3	141,350
6	Building stone	....	....	....	19,000,000	....	....	19,000,000
7	Cement	Bbls.,300–400lb.	4,150,000	....	3,492,500	4,500,000	....	3,990,000
8	Coal, anthracite	Long tons	34,241,047	34,800,338	76,698,000	34,865,576	35,435,067	76,145,000
9	Coal, bituminous *c*	" "	66,303,427	67,386,423	84,205,009	67,509,684	68,612,386	80,507,000
10	Cobalt oxide	Pounds	8,423	3.8	....	8,689	3 9	....
11	Corundum	Short tons	600	544	108,000	645	655	116,190
12	Chrome ore	Long tons	2,700	2,744	40,000	2,000	2,033	30,000
13	Feldspar	" "	13,600	13,822	68,000	14,900	15,143	74,500
14	Flint	" "	30,000	30,489.9	120,000	30,000	30,489	120,000
15	Fluorspar	Short tons	5,000	4,537.2	22,500	5,000	4,537.2	22,000
16	Grindstones	....	....	....	500,000	....	....	250,000
17	Gypsum	Short tons	90,405	82,186	405,000	95,250	86,434	428,625
18	Infusorial earth	" "	1,000	909	5,000	1,200	1,089	6,000
19	Lime	Bbls., 200 lbs.	40,000,000	3,636,363	20,000,000	42,500,000	3,901,996	21,250,000
20	Limestone for iron flux	Long tons	3,356,956	3,410,667	1,678,478	4,717,163	4,794,194	2,830,297
21	Manganese ore	" "	23,258	23,637	190,281	30,193	30,686	277,636
22	Marls	Short tons	875,000	794,010.9	437,500	800,000	725,953	400,000
23	Mica	Pounds	92,000	42	161,000	40,000	18.1	70,000
24	Millstones	....	....	....	100,000	....	....	140,000
25	Mineral paints	Long tons	3,950	4,014	43,575	15,800	16,058	285,000
26	Mineral waters	Gallons	9,148,401	....	1,312,845	8,950,317	....	1,284,070
27	Natural gas	....	....	....	4,857,200	....	....	10,012,000
28	Novaculite	Pounds	1,000,000	453.7	15,000	1,160,000	526.3	15,000
29	Ozokerite (refined)	"	*a*	....	....	*a*	....	....
30	Petroleum *j*	Bbls., 42 gals.	21,847,205	3,060,311	19,198,243	28,064,841	3,931,277	19,996,313
31	Phosphate rock	Long tons	437,856	445,006.1	2,846,064	430,549	437,579	1,872,936
32	Plumbago	Pounds	327,883	149	26,231	415,525	188.3	33,242
33	Potters' clay	Long tons	36,000	36,587	275,000	40,000	40,653	325,000
34	Pyrites	" "	49,000	49,800	220,500	55,000	55,895	220,000
35	Precious stones	....	....	....	209,900	....	....	119,056
36	Rutile	Pounds	600	*272.4	2,000	600	*272.4	2,000
37	Salt	Bbls., 280 lbs.	7,038,653	901,089	4,825,345	7,707,081	986,115	4,825.345
38	Slate (for pigment)	Long tons	1,975	2,007	24,687	3,000	3,048	30,000
39	Soapstone	Short tons	10,000	9,074.4	200,000	12,000	10,899	225,000
40	Sulphur	" "	715	648.8	17,875	2,500	2,268.5	75,000
41	Talc (fibrous)	" "	10,000	9,074.4	110,000	12,000	10,889	125,000
42	Zinc-white	" "	15,000	13,624.5	1,050,000	18,000	16,344	1,440,000
	Total value of non-metallic mineral products		....	....	$243,101,308	....	....	$247,208,210
	METALLIC.							
43	Aluminum, value at N. Y.	Pounds	283	283 lbs.	$2,550	3,000	1.7	$27,000
44	Antimony, value at S. Fran.	Short tons	50	45.3	10,000	35	31.7	7,000
45	Copper, value at N. Y. *h*	Pounds	170,094,182	77,175	18,292,999	162,241,535	73,612	16,630,660
46	Gold, coining value	Troy ounces	1,538,376	*47,847	31,801,000	1,881,250	*58,512	34,869,000
47	Pig-iron, value at N. Y.	Long tons	4,044,524	4,110,572	64,712,400	5,683,326	6,521,940	95,195,760
48	Lead, value at N. Y.	Short tons	129,412	117,434	10,469,431	135,629	123,075	12,667,749
49	Nickel, value at N. Y. *i*	Pounds	277,904	126	179,975	214,992	97.5	127,157
50	Platinum (crude)	Troy ounces	250	....	187	50	....	100
51	Quicksilver, value at S. F.	Flasks, 76½ lbs.	32,073	1,116.6	979,189	29,981	1,043.3	1,060,000
52	Silver, coining value	Troy ounces	39,910,279	*1,241,321	51,600,000	39,445,312	*1,226,859	51,321,500
53	Tin	Pounds	....	....	....	....	....	....
54	Zinc, value at N. Y.	"	40,688	36,931	3,539,856	42,641	38,694	3,752,408
	Total value of metallic mineral products		....	....	$181,587,587	....	....	$215,658,334
	Total value of non-metallic mineral products		....	....	243,101,308	....	....	247,208,210
	Estim. value of mineral products, unspecified *g*		....	....	5,000,000	....	....	5,000,000
	Grand total		....	....	$429,688,895	....	....	$467,866,544

* Kilograms.

† Short tons = 2000 lbs. ‡ Long tons = 2240 lbs. § Metric tons = 2204 lbs.

(*a*) Not reported.

(*b*) Including aluminum in alloys.

(*c*) Including brown coal and lignite.

(*e*) Value of crude product.

THE UNITED STATES—*Continued.*

1880 to 1892.

1887.			1888.			1889.			
Quantity.		Value at Place of Production	Quantity.		Value at Place of Production	Quantity.		Value at Place of Production	No.
Customary Measures	Metric Tons.		Customary Measures.	Metric Tons.		Customary Measures.	Metric Tons.		
150	136.1	$4,500	100	90.7	$3,000	30	27.2	$1,800	1
4,000	3,629.5	16,000	53,800	48,811	331,500	51,735	46,955	171,537	2
15,000	15,244	75,000	20,000	20,326	110,000	19,161	19,473	106,313	3
7,601,115	3,448	380,055	6,813,443	3,091	408,800	7,273,132	3,299	454,571	4
199,087	90.3	61,717	307,386	139.5	95,290	418,891	190	125,667	5
....	....	25,000,000	....	....	25,500,000	....	....	42,809,706	6
6,692,744	....	5,674,377	6,503,295	....	5,021,139	7,000,000	....	5,000,000	7
37,591,246	38,205,259	84,558,000	41,637,110	42,317,208	89,027,000	35,420,209	35,998,760	57,313,000	8
79,350,990	80,647,105	99,103,000	88,247,002	89,688,424	98,664,000	87,898,265	89,334,004	97,125,000	9
5,769	2.6	....	7,491	3.4	....	12,955	6.9	....	10
600	544	108,000	589	535	91,620	2,245	2,038	105.565	11
3,000	3,049	40,000	1,500	1,524	20,000	2,000	2,032	30,000	12
10,200	10,366	56,100	8,700	8,842	50,000	6,970	7,083	39,370	13
32,000	32,522	185,000	30,000	30,489	175,000	11,113	11,294	49,137	14
5,000	4,537.2	20,000	6,000	5,453.8	30,000	9,500	8,621	45,835	15
....	....	224,400	....	....	281,800	....	....	439,587	16
95,000	86,207	425,000	110,000	99,819	550,000	267,769	242,985	764,118	17
3,000	2,722	15,000	1,500	1,361	7,500	3,466	3,154	23,372	18
46,750,000	4,242,286	23,375,000	49,087,000	4,451,814	24,543,500	68,474,668	6,213,672	33,217,015	19
5,377,000	5,464,806	3,226,200	5,438,000	4,529,334	2,719,000	6,318,000	6,421,172	3,159,000	20
34,524	35.087	333,844	29,198	29,674	279,571	24,197	24,592	240.559	21
600,000	544,465	300,000	300,000	272,232	150,000	139,522	126,608	63,956	22
70,000	31.8	142,250	48,000	21.7	70.000	49,500	22.4	50,000	23
....	....	100,000	....	....	81,000	....	....	35,155	24
20,000	20,326	310,000	24,000	24,391	380,000	32,307	32,924	463,766	25
8,259,609	....	1,261,463	9,578,648	....	1,679,302	12,780,471	....	1,748,458	26
....	....	15,817,500	....	....	22,629,875	....	....	21,097,099	27
1,200,000	544.4	16,000	1,500,000	681	18,000	5,982,000	2,714	32,980	28
a	....	....	43,500	19.7	3,000	50,000	22.7	2,500	29
28,278,866	3,961,257	18,877,094	27,612 025	3,867,848	17,947,620	35,163,513	4,925,647	26,963,340	30
480,558	488.005	1,836,818	448,567	455,892	2,018,552	550,245	559,233	2,937,776	31
416,000	188.7	34.000	400,000	182	33,000	....	....	*e*72,662	32
43,000	43,702	340,000	36,750	36,750	300,000	294,344	299,150	635,578	33
52,000	52,849	210.000	54,331	55,218	167,658	93,705	95,275	202,119	34
....	....	163,600	....	....	139,850	....	....	188,807	35
1,000	*454	3,000	1,000	*454	3,000	1,000	*454	3,000	36
8,003,962	1,228,953	4,093,846	8,055,881	1,030,743	4,374,203	8,005,565	1,030,702	4,195,412	37
2,000	2,032	20,000	2,500	2,540	25,000	2,000	2,032	20,000	38
12,000	10,899	225,000	15,000	13,612	250,000	12,715	11,538	231,708	39
3.000	2,722	100,000	*i*	....	....	450	408	7,850	40
15,000	13,611	160,000	20,000	18,148	210,000	23,746	21,549	244,170	41
18,000	16,344	1,440,000	20,000	18,149	1,600,000	16,970	15,390	1,357,600	42
....	....	$288,331,764	....	....	$299,988,780	....	....	$301,775,088	
18,000	10.2	$59,000	19,000	8.6	$65,000	*b*47,468	21.5	97,335	43
75	68.9	15.000	100	90.7	20,000	115	104.3	28.000	44
185,246,000	84,049	21,115,916	233,729,000	106,047	34,194,170	244,729,000	111.038	28,646,300	45
1,596,500	*49,655	33,136,000	1,604,927	*49.917	33,167,500	1,590,869	*49,480	32,886.744	46
6,417,156	6,521,940	121,925,800	6,489,738	6,595,715	107,000,000	7,603,640	7,727,809	120,000,000	47
160,700	145,827.5	14,463,000	180,555	163,843	15,924,951	182,967	166,031	16,137.689	48
205,566	93.3	133,200	204,328	92.5	127,632	217,663	99	130,598	49
448	....	1,838	500	....	2,000	500	....	2,000	50
33,997	1,183	1,436,000	33,250	1,125.7	1,413,125	26,484	921.6	1,190,500	51
41,269,240	*1,283,588	53,941,800	45,783,632	*1,423,999	59,206,700	51,354,851	*1,596,999	66,396,988	52
....	....	....	....	....	....	....	....	....	53
50,340	45,680.5	4,782,300	55,903	50,729	5,500,855	58,860	53,412	5,791.824	54
....	....	$250,909,854	....	....	$256,623,933	....	....	271,307,978	
....	....	288,331,764	....	....	299,988,780	....	....	301,775,088	
....	....	5,000,000	....	....	5,000,000	....	....	10,000,000	
....	....	$544,241.618	....	....	$561,612,713	....	....	583,083.066	

(*g*) Including fire-clay, common brick-clay, terra cotta, building sand, glass sand, limestone used as flux in lead-smelting, limestone used in glass-making, iron where used as flux in lead-smelting, tin ore, iridosmine, nitrate of soda, carbonate of soda, sulphate of soda, native alum, mineral soap, strontia, and pumice-stone.

(*h*) Including copper from imported pyrites, except in 1881, for which no returns are available.

(*i*) Including nickel in copper-nickel alloy and in exported ore and matte.

(*j*) The production of petroleum stated in gallons is calculated in kiloliters, and converted to metric tons, by multiplying by 0.88. This, of course, gives a result only approximately correct, as the specific gravity of the various kinds of oil varies.

MINERAL PRODUCTION OF

Calendar years

No.	Products.	Customary Measures.	1890. Quantity. Customary Measures	1890. Quantity. Metric Tons.§	1890. Value at Place of Production	1891. Quantity. Customary Measures	1891. Quantity. Metric Tons.	1891. Value at Place of Production
	NON-METALLIC.							
1	Asbestos	Short tons†	71	64.3	$4,560	66	59.8	$3,960
2	Asphaltum	“ “	40,841	37,061	190,416	45,054	40,884	242,264
3	Barytes (crude)	Long tons ‡	21,911	22,180	86,505	31,069	31,576	118,363
4	Borax	Pounds	11,889,828	5,394	760,770	11,830,000	5,367	768,950
5	Bromine	“	387,847	176	104,719	368,786	167	73,757
6	Building stone	....	....	....	47,000,000	....	....	47,294,746
7	Cement	Bbls., 300–400 lb.	8,000,000	....	6,000,000	8,222,792	....	6,680,951
8	Coal, anthracite	Long tons	41,502,357	42,180,257	66,395,772	45,249,492	45,988,594	76,019,145
9	Coal, bituminous *c*	“ “	97,849,081	99,447,339	108,708,000	106,129,033	107,862,538	118,864,516
10	Cobalt oxide	Pounds	6,788	3	....	7,200	3.3	....
11	Corundum	Short tons	1,970	1,789	89,395	2,265	2,055	90,230
12	Chrome ore	Long tons	3,599	3,657	53,985	1,372	1,396	20,580
13	Feldspar	“ “	8,000	8,130	45,200	10,000	10,163	50,000
14	Flint	“ “	13,000	13,212	57,400	15,000	15,245	60,000
15	Fluorspar	Short tons	8,250	7,486	55,328	6,320	5,735	38,000
16	Grindstones	....	....	....	450,000	....	....	476,113
17	Gypsum	Short tons	182,995	166,057	574,523	208,126	188,862	628,051
18	Infusorial earth	“ “	2,532	2,298	50,240	....	....	21,988
19	Lime	Bbls., 200 lbs	60,000,000	5,444,646	35,000,000	60,000,000	5,444,646	35,000,000
20	Limestone for iron flux	Long tons	5,521,622	5,611,790	2,760,811	5,000,000	5,081,650	2,300,000
21	Manganese ore	“ “	25,684	26,103	219,050	23,416	23,898	239,129
22	Marls	Short tons	153,620	139,401	69,880	135,000	122,505	67,500
23	Mica	Pounds	60,000	27.1	75,000	75,000	34	100,000
24	Millstones	....	....	....	23,720	....	....	16,587
25	Mineral paints	Long tons	45,732	46,478	661,992	47,562	48,430	658,478
26	Mineral waters	Gallons	13,907,418	....	2,600,750	18,392,732	....	2,996,259
27	Natural gas	....	....	....	18,742,725	....	....	15,500,084
28	Novaculite	Pounds	....	....	69,909	1,375,000	628	150,000
29	Ozokerite (refined)	“	350,000	158.9	26,250	50,000	23	3,000
30	Petroleum *j*	Bbls., 42 gals	45,822,672	6,418,765	35,365,105	57,024,891	7,978,923	34,214,935
31	Phosphate rock	Long tons	510,499	518,835	3,213,795	587,988	597,589	3,651,150
32	Plumbago	Pounds	....	....	*e*77,500	1,506,065	684	75,350
33	Potters' clay	Long tons	350,000	355,715	756,000	400,000	406.532	900,000
34	Pyrites	“ “	111,836	113,652	273,745	109,319	111,105	317,280
35	Precious stones	....	....	....	118,833	....	....	235.300
36	Rutile	Pounds	400	*181.6	1,000	300	304	800
37	Salt	Bbls., 280 lbs	8,776,991	1,127,092	4,752,286	10,233.701	1,300,107	5,639,083
38	Slate (for pigment)	Long tons	2,000	2,032	20,000	2,000	2,032	20,000
39	Soapstone	Short tons	13,670	12,404	252,309	16,514	14,985	243,981
40	Sulphur	“ “	*a*	....	....	1,200	1,089	39,600
41	Talc (fibrous)	“ “	41,354	37,526	389,196	53,054	48,143	493,068
42	Zinc-white	“ “	....	....	1,600,000	....	....	1,600,000
	Total value of non-metallic mineral products		....	....	$337,696,669	....	....	355,913,198
	METALLIC.							
43	Aluminum, value at N. Y.	Pounds	*b*61,281	27.8	61,281	168,075	76	$126,056
44	Antimony, value at S. Fran.	Short tons	129	117	40,756	455	413	45.500
45	Copper, value at N. Y. *h*	Pounds	265,878,000	120,607	30,930,800	297,600,000	135,027	38,522,500
46	Gold, coining value	Troy ounces	1,588,880	*49,418	32,845,000	1,604.840	*49,915	33,175.000
47	Pig-iron, value at N. Y.	Long tons	9,202,702	9,352,983	151,200,410	8,279,870	8,415,079	140,757,790
48	Lead, value at N. Y.	Short tons	161,754	146,780	14,266,703	202,000	183,303	17,574.000
49	Nickel, value at N. Y. *i*	Pounds	200,332	91	130,216	120,848	55	72,509
50	Platinum (crude)	Troy ounces	600	....	2,500	450	....	3,150
51	Quicksilver, value at S. F.	Flasks, 76½ lbs.	22,926	797.8	1,203,615	22,926	777.13	1,037,381
52	Silver, coining value	Troy ounces	54,500,000	*1,695,102	70,485,714	58,330,000	*1,814,226	75,416,565
53	Tin	Pounds	....	....	....	125.198	56.8	25,085
54	Zinc, value at New York	Short tons	67,342	57,789	7,474,962	80,263	72,834	8,058,405
	Total value of metallic mineral products		....	....	308,641,957	....	....	314,818,941
	Total value of non-metallic mineral products		....	....	337,696,669	....	....	354,273,449
	Estim. value of mineral products, unspecified *g*		....	....	10,000,000	....	....	10,000,000
	Grand total		....	....	656.338.626	....	....	679.087,390

* Kilograms.

† Short tons = 2000 lbs. ‡ Long tons = 2240 lbs. § Metric tons = 2204 lbs.

(*a*) Not reported.

(*b*) Including aluminum in alloys.

(*c*) Including brown coal and lignite, and anthracite mined elsewhere than in Pennsylvania.

(*e*) Value of crude product.

THE UNITED STATES—*Continued.*

1880 to 1892.

1892. Quantity. Customary Measures	Metric Tons.	Value at Place of Production	No.
100	90.7	$5,000	1
54,985	49,896	291,250	2
26,500	26,932	106,000	3
14,243,099	6,462	925,810	4
379,480	172	64,512	5
....	....	45,000,000	6
8,465,953	....	6,586,098	7
46,862,950	47,615,447	78,729,756	8
113,851,373	115,679,523	127,513,537	9
8,600	4	6,450	10
2,200	1,997	88,000	11
3,000	3,048	30,000	12
16,000	16,262	60,000	13
16,000	16,262	64,000	14
9,000	8,167	54,000	15
....	....	500,000	16
225,000	204,175	675,000	17
....	....	20,000	18
70,000,000	6,352,087	38,500,000	19
4,560,000	4,634,750	2,097,600	20
17,000	17,277	170,000	21
135,000	122,505	67,500	22
75,000	34	100,000	23
....	....	16,000	24
50,000	50,817	650,000	25
....	....	3,000,000	26
....	....	13,000,000	27
....	....	150,000	28
130,000	58.9	7,800	29
57,167,906	7,998,933	31,442,348	30
641,382	651,801	2,361,219	31
1,298,363	589	64,920	32
450,000	457,349	1,000,000	33
106,250	107,985	357,000	34
....	....	188,000	35
300	304	800	36
11,585,754	1,471,875	5,879,222	37
....	....	20,000	38
19,000	17,241	266,000	39
1,825	1,656	54,750	40
51,000	46,279	459,000	41
....	....	1,200,000	42
....	....	$361,771,572	
294,313	134	$191,303	43
478	433	51,600	44
335,380,000	152,168	37,850,000	45
1,596,516	*49,657	33,000,000	46
9,120,413	9,269,349	136,806,915	47
218,500	198,276	17,917,000	48
96,152	43	57,691	49
350	....	1,750	50
27,995	974.06	1,119,720	51
64,900,000	2,018,616	83,909,210	52
143,400	65	29,827	53
83,300	75.589	7,703,580	54
....	....	$318,638,596	
....	....	350,959,283	
....	....	10,000,000	
....	....	$679,597,879	

The production of gold and silver in 1892, though given in the table (p. 187) which is credited to the Director of the Mint, was really obtained by direct returns from each refiner in the United States to this work, and, in the amount of silver produced differs very materially from the estimate of the Director of 58,000,000 ounces, which is intended to represent the amount of silver produced from ores actually mined in 1892. Our estimate, following the common previous practice in the reports of the Director of the Mint, gives the amount of silver actually refined and put in final marketable form during the year.

There has been no great increase in 1892 in the total value of the mineral products of the United States as estimated in these tables, nevertheless the production of most of the minerals and metals has increased in quantity materially. It is natural that with increasing facilities and competition in producing, both costs and market values should decline, and in most cases profits have also been less than formerly. The disadvantages this vast country labors under in having to transport its raw material and manufactured goods enormous distances to market, with consequent high cost for carriage, are being overcome in part by the creation of markets nearer the sources of supply ; in part by the reduction in freights due to competition among railroads and the possibility of reducing charges by reason of increasing quantities carried; and in part by the great reductions in cost of producing which cheaper supplies, larger output, and greater experience, skill, and knowledge of the business have rendered possible. When coal is carried by rail at one quarter of a cent per ton-mile, and many other articles pay less than half a cent per ton-mile, distance becomes a less important element in the development of an industry. That coal is delivered on board vessels four hundred miles from the mines at $2 and $2.25

(*g*) Including fire-clay, common brick-clay, terra cotta, building sand, glass sand, limestone used as flux in lead-smelting, limestone used in glass-making, iron where used as flux in lead-smelting, tin ore, iridosmine, nitrate of soda, carbonate of soda, sulphate of soda, native alum, mineral soap, strontia, and pumice-stone.

(*h*) Including copper from imported pyrites, except in 1881, for which no returns are available.

(*i*) Including nickel in copper-nickel alloy and in exported ore and matte.

(*j*) The production of petroleum stated in gallons is calculated in kiloliters, and converted to metric tons, by multiplying by 0.88. This, of course, gives a result only approximately correct, as the specific gravity of the various kinds of oil varies.

per ton, and both mines and roads make satisfactory dividends; that it is mined at a fair profit though sold on the railroad at the mines for, say, 65c. a ton; that hard, free-milling gold ores are mined and milled at $1.25 a ton, and 95% of the gold is extracted from sulphide ores at a treatment cost of $2.50 a ton; that copper ores are mined, milled, concentrated, smelted, and refined at $1.50 a ton, and 62% high-grade Bessemer iron ore can be delivered a thousand miles from the mines at, say, $3.50,—that such instances of cost of production are possible with average wages at from $2 to $3.50 per day, and that the cost of transportation added still permits these selling prices, are mentioned as examples of the best present practice, and not as examples of average costs.

The average commercial cost of producing any article is the average minimum cost at which so much of it can be produced as the market demands. The more expensive producers are the first to be obliged to stop; the most economical, the fittest, survive, and regulate the market.

The enormous progress in the mineral industry of the United States which is shown in these eloquent statistics has been due chiefly to increasing knowledge and experience in the arts involved. The great reduction in costs of production has in most cases been accompanied by a decided betterment in the condition of the wage-earning classes, if not by an absolute increase in the rates of daily wages. Skill and knowledge count for more than the rates of wages in the successful prosecution of an industry. Nor is the importance of knowledge by any means confined to the "captains of industry" or those who create or develop it, but it is quite as important in the workmen. The introduction of greater skill and knowledge which result in improving the quality of the work and increasing the output per man per day is the most effective and satisfactory manner of bringing about a reduction in cost to the producer; while no advance in wages ever asked for or received could so greatly benefit the wage-earners as would greater knowledge of *their* business by the wives and daughters of workers. A better knowledge of what and how to cook, of how to keep house, and of the common rules and means for promoting health would be of incalculable benefit to the wage-earners, bettering their condition in many ways, and it would at the same time indirectly tend to promote economy and success throughout the entire industry.

The unbounded natural resources and the intelligence and marvelous energy of our people have brought the development of many departments of the mineral industry to the point where, exceeding the home consumption, we must open the wider markets of the world, and make of this country a workshop for supplying other and less fortunate nations.

The results recorded in this volume demonstrate the existence of vast natural resources, and of marvelous energy and intelligence in developing them, and it is natural that other countries witnessing this rapid creation of great wealth and prosperity should seek here its causes. A study of the current history of the mineral industry in all its departments, as recorded from week to week in the pages of the *Engineering and Mining Journal*, will elucidate the solution of this problem. The results only are given in this composite photograph of a great industry.

ALUMINUM.

By H. N. Yates.

Aluminum is very widely distributed in nature, yet there are few minerals which can serve as sources of the metal. Some of these are: Bauxite ($Al_2O_6H_6$), a limonite in which most of the iron is replaced by aluminum, soft and granular, with 50% to 70% alumina; corundum (Al_2O_3), crystalline and very hard, specific gravity 4, generally quite pure, but too valuable for abrasive purposes to be used as an ore; diaspore ($H_2Al_2O_4$), hard and crystalline, specific gravity 3.4, with 64% to 85% alumina, and ordinarily quite pure; gibbsite ($H_6Al_2O_6$), stalactitic, specific gravity 2.4, containing, when pure, 65% alumina; aluminite or alunogen ($Al_2SO_6 + 9H_2O$), specific gravity 1.66, a sulphate of aluminum, found in large beds, chiefly along the Gila River in New Mexico, containing about 30% alumina, and easily soluble in water; cryolite ($Al_2F_6.6NaF$), specific gravity 2.9, easily fusible, —and when fused its specific gravity is about 2,—containing 40% aluminum fluoride and 60% sodium fluoride. Clays all contain a large percentage of aluminum, but always in the state of silicate; and the difficulty of removing this silica has so far prevented the employment of clay as an ore of aluminum.

Of the ores above named, bauxite is the most important. It occurs in Tennessee, Virginia, North Carolina, South Carolina, Georgia, Alabama, and Arkansas. The discovery of bauxite in Arkansas is due to Dr. John C. Branner, State Geologist, who announced it in the early part of 1891. The deposits there are said to cover a large area and to vary in thickness from a few feet to over 40 ft., but have not been so well opened as those of Alabama. Bauxite used in the manufacture of alumina is worth about $10 per ton, delivered. Another mineral much used in the electrolytic aluminum processes is cryolite, which is imported from Ivigtôk, Greenland. It is found to some extent in the western part of the United States, but the only commercial source at present is Greenland. The imported cryolite sells for seven cents per pound in barrel lots in New York.

To prepare pure alumina (Al_2O_3) for the use of the aluminum manufacturer bauxite is treated, either by fusing it with carbonate of soda and dissolving in water, or by boiling it with a strong solution of caustic soda. In either case a solution of sodium aluminate is obtained, which is filtered from the residue of silica and ferric oxide and decomposed into aluminum hydrate and carbonate of soda by pumping carbonic acid gas through it. After a thorough washing the hydrate is calcined at a high heat and the resulting alumina finely ground.

Sir Humphry Davy was the first to attempt the reduction of alumina. He tried, in 1807, to reduce alumina by connecting a lump of the moist oxide with one pole of the battery and dipping the other terminal into a globule of mercury contained in a hollow in the lump. His expectation of obtaining an amalgam of aluminum was not realized, and he abandoned the attempt. A further effort to reduce the oxide by means of potassium vapor was also a failure.

After many other ingenious attempts to reduce alumina, silica, and the other earths in combination with soda and potash, he abandoned the work. At the close of his paper in the *Philosophical Transactions of the Royal Society* (London, 1808, he says: "Had I been so fortunate as to have obtained more certain evidences on this subject and to have procured the metallic substances I was in search of, I should have proposed for them the names of 'silicium,' 'alumium,' 'zirconium,' and 'glucium.'" It was not until Wöhler, in 1827, replaced the oxide of aluminum by the newly discovered chloride that the reduction by potassium was successful. But he only obtained the metal in the form of a fine gray powder, and not in a coherent mass. By varying his experiment and passing the vapor of potassium over the heated chloride, he succeeded, in 1845, in obtaining some minute metallic globules. Working with these pinhead buttons, he performed the remarkable feat of determining with considerable accuracy most of the physical and chemical characteristics of the metal. In 1854 Henri St. Claire Deville set to work to prove the existence of a protoxide of aluminum corresponding to the protoxide of iron. Repeating Wöhler's experiment, he obtained a gray metallic powder. This he melted with aluminum chloride (Al_2Cl_6), thinking the aluminum would combine with part of the chlorine and form a subchloride. His hopes were disappointed. He obtained instead some finer buttons of aluminum. Recognizing the importance of this result, he abandoned his search for the protoxide and gave his whole attention to the perfection of a commercial process for the reduction of aluminum. Aided by liberal patronage from the French Academy and from the Emperor Napoleon, he not only succeeded in perfecting Wöhler's original process, but he reduced the price of sodium from 2000 francs per kilo to 10 francs. In 1855 he exhibited at the Paris Exposition an ingot and some articles manufactured from aluminum labeled "Silver made from Clay."

The first works for the manufacture of aluminum were built at Rouen in 1855, and operated by Tissier Brothers, using Deville's process. Deville also applied himself to improving the manufacture of alumina from bauxite. It was due entirely to his great genius that the aluminum industry was put upon a working basis, and so perfect were his methods that they remained practically unchanged for the next 30 years.

While Deville was working on these early experiments for the chemical reduction of aluminum, both he and Bunsen, working independently, had proved the possibility of reducing the metal from the double chlorides of aluminum and sodium by means of the electric current.

In 1855 H. Rose of Berlin and Dr. John Percy of London, without knowledge of each other's work, succeeded in reducing aluminum from cryolite, using sodium as the reducing agent. In 1856 Deville repeated these experiments and said, "I have, furthermore, reduced cryolite mixed with sodium chloride by the battery." He also pointed out the fact that a double chloride or a cryolite bath, decomposed

by the battery, could be maintained constant, or be regenerated by the use of carbon anodes, containing an excess of alumina. Herein Deville shows himself to be the inventor of the present electrolytic processes for the reduction of aluminum from a fluoride bath. It was manifestly nothing but the high cost of electricity at that time and the difficulty of securing suitable vessels which prevented him from perfecting and carrying out this process commercially.

From 1860 to 1874 Bell Brothers carried on the manufacture of aluminum by the Deville sodium process at Newcastle-on-Tyne, at which time the price ranged from $10 to $12 a pound.

From 1874 to 1882 Merle & Co. of Salindres, France, were the only producers of aluminum. Their monopoly was broken by Mr. Webster, who had patented processes for the production of alumina and aluminum chloride. In 1882 he formed the Aluminum Crown Metal Company and established large works near Birmingham. In 1887 this company was merged into the Aluminum Company, Limited, and operated under the Webster patents for the production of aluminum chloride and alumina, and under the Castner patents for the production of sodium. Mr. H. Y. Castner is an American, and his improved process for the manufacture of sodium has greatly cheapened that metal. Owing to these improvements on the old Deville process, the Aluminum Company, Limited, was enabled to reduce the price of pure aluminum to about five dollars per pound. This price was not allowed to stand very long, however, and the severe competition of the cheap electric processes then coming forward compelled the company to retire from the field, and its splendid plant is now devoted to the manufacture of sodium.

The principal electric process was Grätzel's, patented in 1883 and operated by the Aluminum und Magnesium Fabrik, Pt. Grätzel, near Bremen, Germany. Grätzel's salt was a double fluoride of aluminum and sodium, and he regenerated it by means of compressed pencils of alumina and carbon, using iron crucibles, heated by external furnace heat, in which the electrical decomposition took place.

The Cowles patents came out in 1885 and were used by the Cowles Electric Smelting and Aluminum Company, of Lockport, N. Y., and the Cowles Syndicate Company, Limited, of Stoke-upon-Trent, England. This process combined the principles of electric heating with electrolysis and the reducing action of carbon on all refractory oxides and ores, such as alumina, silica, etc.

Kleiner of Zurich patented a process in 1886 for the electrolysis of cryolite alone, and started an experimental plant in England, but it never became a commercial success.

Heroult's process, patented abroad in 1887 and in the United States in 1888, is in two parts. The first is an alloy process; the second refers to the electrolytic decomposition of a fluoride bath regenerated with alumina. A German company, the Aluminum Industrie Actien-Gesellschaft, with a capital of 10,000,000 francs, works this process at Neuhausen on the Rhine. This company is now the largest producer of aluminum in the world.

About three years ago the United States Aluminum Metal Company was organized with a small plant at Boonton, N. J., to operate under the Heroult patents. It worked for a while in an experimental way, but has never put its products on the market. Heroult's patents are operated in France by the Société Métallurgique at Froges (Isère).

Charles M. Hall's patent, 1889, describes a bath composed of aluminum fluoride and the fluoride of a metal more electro-positive than aluminum, through which a current is passed, and fresh alumina added from time to time to regenerate the salt. This process is being worked in the United States by the Pittsburg Reduction Company, of Pittsburg, Pa., and in England by the Metal Reduction Company. The aluminum market in this country is now entirely supplied by the Pittsburg and Cowles companies. The Willson Aluminum Company is operating at Spray, N. C., under the Willson patents, but so far has put only small quantities of alloys on the market.

The electrolytic is the only method for the manufacture of pure aluminum being carried on at the present day. In this country and in England the Cowles and Hall processes are used, and on the Continent the Heroult and Minet; but as carried out they are all practically the same, viz., a modification of the old Deville-Bunsen process, employing, however, the heat of the current to maintain the fusion. A brief description of the operation of one will suffice for all, so far as concerns the essential principles.

The furnace is a rectangular iron box, open on top, and lined on the inside with a thick carbon bottom and walls. The whole furnace is made the negative electrode, and is connected with the dynamo by means of heavy copper rods. The anode consists of a number of carbon cylinders, 3 in. in diameter by from 14 to 20 in. long, clamped to and suspended from a copper bar running parallel to the axis of the furnace, and a few feet above it. In practice several of the furnaces are connected in series, their number depending directly on the current generated by the dynamo. For instance, a current of 50 volts and 3000 amperes will supply a series of 6 furnaces, thus giving each furnace about 8 volts and 3000 amperes, which is about the strength of current required for the operation.

To start a furnace, the carbon cylinders are lowered till they touch the carbon bottom. A poor contact is thus formed, and the ground cryolite, which is then piled around the carbons, is melted by the resistance. When enough has been melted to form a good bath, the carbons are raised, and the melted cryolite carries the current and becomes the electrolyte. The resistance is very high until alumina is added to the bath and dissolved there, when it falls suddenly, and the difference of potential between the electrodes becomes constant at from 6 to 10 volts. A sudden rise in voltage indicates, therefore, very clearly when the alumina has been all reduced, and when more must be added. The process is continuous, day and night, seven days a week. The metal which collects in the bottom of the furnace is removed every 24 hours. The metal made by this process is very pure, most of it running above 99% aluminum, and by using extra-pure materials it may be made to approximate very nearly to 100%.

The most notable characteristic of aluminum is its low specific gravity—2.6 for castings and 2.74 for wire. No other metal in common use approaches it for lightness. Aluminum is not a rival of steel, and may never replace iron as a structural material; but it is a rival of brass, copper, tin, nickel, and white alloys, and is replacing them in many directions. In tensile strength it ranks with cast-iron, breaking at 15,000 to 20,000 lbs. per sq. in., but in malleability and ductility it ranks with the noble metals. Like gold and silver, it hardens very rapidly in working, and rods and wire vary in strength from 26,000 to 62,000 lbs. per sq. in.

Its elastic limit is about half its tensile strength, and its elongation 10% to 20% in one inch.

The electrical conductivity of aluminum is about 50 with copper at 90 and silver at 100. Its thermal conductivity is about 38, copper 73.6, and silver 100. Undoubtedly the conductivity of chemically pure aluminum is much higher, the sample tested containing about 1.5% impurities.

Aluminum is a little softer than silver, but its ductility allows it to be drawn, punched, or spun into almost any form. A great deal of sheet metal is being used for this purpose, and much more would be used if it were not for the fact that a slightly bluish tint detracts from its resemblance to silver. Practically, aluminum is non-tarnishable; but strictly speaking, after long exposure to the atmosphere its polish becomes dulled by a very thin film of white oxide, which seems to protect it from further deterioration. Sulphuretted hydrogen has no action on it.

It is inert in most of the acids. Hydrochloric acid and the fixed alkalies are its true solvents. It has been claimed by certain German chemists that aluminum is attacked by almost all vegetable acids, even tea and beer having a solvent action upon it. This statement has repeatedly been proved to be untrue. Even strong brine has been shown to have a very inconsiderable action upon it. The mistake was due to the use of aluminum foil, as it is well known that almost all metals when in a fine state of division are attacked by reagents that have no action on them in bulk.

The specific heat of aluminum is very high (0.2253), being about double that of iron; consequently, although its melting point is low, about 700° C., it takes a long time for it to become fluid, and an equally long time for it to set. Founders do not usually realize this, and the melted metal appearing rather thick, they generally make the mistake of pouring it too hot.

Aluminum is not volatile at any heat obtainable by ordinary combustion of carbon; but a thin, tenacious film of oxide forms on the surface of the melted metal, which protects it from further oxidation. Aluminum is very sonorous in the form of a bar, but not when cast into a bell. This is probably explained by the fact, noticed by Faraday, that a note is compound, being formed of a tone audible in the longitudinal direction and another in the transverse.

The alloys of aluminum are divisible into two classes—those containing less than 12% of aluminum and the remainder some other metal, and those containing less than 15% of some other metal and the rest aluminum. In the first class, aluminum bronze, containing 90% copper and 10% aluminum, is the most valuable. Its tensile strength is from 90,000 to 100,000 lbs. per sq. in., and when a little silicon is also present its strength sometimes rises as high as 135,000 lbs. per sq. in. In this class belongs the steel alloy. Greatly increased quantities of aluminum have been used during the past year by steel workers. A fraction of a per cent of aluminum is added to the steel, generally for the purpose of obtaining sound clean castings, and it is probable that half the steel castings made at the present day are rendered free from "blow-holes" by the addition of small amounts of aluminum. To the second class belong numerous alloys of aluminum with small percentages of copper, tin, zinc, silver, or titanium added for hardening and stiffening purposes.

The demand for aluminum during the past year has been very active, and is steadily increasing. This is owing not only to the low price of the metal, but to a better knowledge of its good qualities on the part of metal-workers, and a consequent widening of the field for its use.

The opening of one important field is due to the success of the Cowles Company in getting seamless tubing drawn from cast ingots. Much aluminum will undoubtedly be employed during the coming year in the manufacture of tubing for industrial and ornamental purposes. The use of aluminum and ferro-aluminum for steel making and casting is coming into wider favor and the amount so used is increasing each year.

Probably the largest use for aluminum still lies in the ornamental field. Innumerable fancy articles formerly made from brass and german silver are now being duplicated in aluminum, and special shapes of wire and rod are desired for architectural purposes. A considerable demand has sprung up during the past year for aluminum patterns and models, the decrease in weight being the chief object sought.

The German Government, and others in less degree, have adopted aluminum for army equipments, such as canteens, sword scabbards, uniform trappings, etc. Other important users of the metal are makers of surgical and scientific instruments, cash registers and conveyers, chains, dog-collars, shoe soles, etc., a company for the manufacture of the last-mentioned articles having recently been established in Ohio.

Thin sheet-aluminum is being adopted as a material for canoes and racing-shells. Horseshoes are forged from the rod, and aluminum in fine powder, mixed with chlorate of potash, is used for photographic flash-lights. A small percentage of aluminum added to babbitt metal greatly improves its qualities, increasing its durability and wearing qualities and its malleability, so that it can be hammered to a thin edge. This permits of its being rolled and formed to shapes where the ordinary method of casting is inadvisable.

The alloys of aluminum with copper are in large demand, and the wire business in 5% aluminum bronze has grown to large dimensions during the past year. Considerable 10% aluminum bronze is being used by brass-founders, not only in the manufacture of aluminum brass, but to act in small doses as a flux for scrap-brass.

The largest use for aluminum bronze is in machinery and engine castings, pump-rods, cylinders, chains, conveyers, and buckets, especially in mine machinery where the acid water corrodes steel or brass.

Owing to the litigation between the several aluminum companies, the manner of regulating the price of aluminum in this country during the past 18 months has in part been in the hands of the United States court. In April, 1891, the court fixed the price at $1.50 per lb. Later, the price abroad fell by the action of European producers to nearly 50c. per lb. In August, 1891, under the ruling of the court, the minimum price was fixed in this country at 50c. per lb. The year 1892 opened with some heavy sales very close to that figure, but in May the court again raised the price and fixed it at 65c. per lb. Since then that price has ruled strictly for large lots, the only reduction being a 10% commission to brokers. The price abroad has also gone up, and is now about the

same as in the United States. The reduction in price has been remarkably rapid. In 1855, the first year of its commercial existence, aluminum sold for $90 per lb. Improvements in methods brought the price down until in 1870 it was about $12 per lb. The next break was in 1885, when the Cowles Company offered 10% bronze for 40c. per lb., equivalent to about $3 per lb. for the contained aluminum. In 1888 the Aluminum Company, Limited, of England, sold pure aluminum for $4.86 (£1) per lb., and the Cowles Company sold it in alloys for about $2 per lb. In 1889 the Pittsburg Reduction Company offered pure aluminum for $2, and last year both the American companies were selling it as low as 50c. per lb.

The history of aluminum shows that its advance in popular favor has been more rapid than that of any other metal. While this may partly be accounted for by the fact that the past century has been pre-eminently a metal-consuming age, it is also largely due to the remarkable and useful qualities of the metal itself.

IMPORTS AND PRODUCTION OF ALUMINUM IN THE UNITED STATES.

Years.	Imports.		Production.		Years.	Imports.		Production.	
	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.	Pounds.	Value.
1870	....	$98	....	....	1882	567	$6,459	....	....
1871	....	341	....	....	1883	426	5,079	83	$875
1872	....	....	....	....	1884	595	8,146	150	1,350
1873	2	2	....	....	1885	439	4,736	283	2,550
1874	683	2,125	....	....	1886	452	5,369	3,000	27,000
1875	434	1,355	....	....	1887	1,260	12,119	18.000	59,000
1876	139	1,412	....	....	1888	1.349	14,086	19,000	65,000
1877	131	1,551	....	....	1889	998	4,840	47.468	97,335
1878	251	2,978	....	....	1890	2,051	7,062	‡61,281	61,281
1879	284	3,423	....	....	1891	*3,921	7,635	168,075	126,056
1880	341	4,042	....	....	1892	*†26	‡1,152	294,313	191,303
1881	517	6,071	....	....					

NOTE.—The imports are given for fiscal years ending June 30 up to 1886; since then, for calendar years.
* Includes unmanufactured only. † Six months. ‡ Including aluminum in alloys.

The production of aluminum at Neuhausen, Switzerland, in 1892 was 286,100 kilos, against 168,669 kilos in the previous year, while the output of the Société Electro-Métallurgique Française, at Froges, France, was 60,000 kilos in 1892 and 40,000 kilos in 1891.

Other uses for aluminum are as an addition in antifriction metals composed of tin and antimony, which it renders more durable.

For ornamental metal-work alloys composed of nickel 20 and aluminum 8; of nickel 40, tin 20, silver 10, and aluminum 30; or of copper 30, cobalt 40, and aluminum 10.

The Cowles alloy, composed of 18 manganese, 13 zinc, 67.5 copper, 5 silicon, and 1.2 aluminum, has a tensile strength of about 26,000 kilos and an elongation of 20%, while its electrical resistance is so great as to adapt it especially for use in rheostats. The Roberts-Austin alloy, composed of 78% gold and 22% aluminum, is of a beautiful ruby-purple color.

It is said that a type-metal composed of 65 parts lead, 20 parts antimony, and 10 parts copper-tin-aluminum alloy is serviceable, and that additions of from 5% to 15% of aluminum to ordinary type-metal composed of 25 parts antimony and 75 parts lead make sharper castings and more durable type.

The great advance that has been made in the metallurgy of aluminum within the past ten years is one of the most hopeful signs of the application of scientific principles to commercial problems. A great deal of laborious and costly work has been done, and the result is that aluminum can be bought for 50 cents per pound as against $12 in 1886; but so far as concerns the future of aluminum, unless it can be made in large quantities, just as lead or copper or zinc, it cannot hope to enter as an important factor in the great industries. It must be smelted in large quantities direct from its ores, or obtained as a bye-product in the preparation of some widely consumed substance, ere it will take in trade the position its qualities command. It is doubtful if the further prosecution of the electrical methods, by which alone aluminum is now made, will bring the cost of it to the point at which it will become a prominent metal, unless they proceed along the line of direct reduction. Even here it is by no means certain that they can make it cheap enough.

There is a very inviting field for research here, and one that to the earnest metallurgist is as attractive as the refining of cast iron was to KELLY and BESSEMER in the early fifties. While the electrical reduction methods are not to be condemned, those who seek by other means to make cheaper aluminum should be encouraged.

ANTIMONY.

BY PROF. J. F. KEMP.

Occurrence.—The almost universal source of antimony is the mineral stibnite, Sb_2S_3, called also antimonite and antimony glance. The oxide senarmontite, Sb_2O_3, is rarely abundant enough to form an ore, and the other compounds are of little more than scientific interest so far as antimony is concerned. The deposits are mostly true veins, in which the ore is distributed through a quartz gangue. In some instances the stibnite is quite pure, but generally it is mixed with much barren vein-stone. Less commonly the deposits assume other forms than true veins, as set forth later under the particular localities.

Arkansas.—There are antimony mines in Sevier County, in the extreme southwestern part of the State. They were discovered as early as 1873, but the most serious work was done on them in 1888–90, in which years the United States Antimony Company, of Philadelphia, extracted about 145 tons of ore. No work is being done at present, and probably none will be attempted until better transportation facilities are secured. The ore is found in veins with quartz gangue, which lie parallel with the bedding of the country-rock (shales). The deposits occur over an area two miles by nine, and along two northeast and southwest anticlines. All the productive claims are controlled by the United States Antimony Company.

California.—Kern, Inyo, and several neighboring counties in the southern central part of this State contain deposits of stibnite, which occur in veins with the usual quartz gangue. The mines at San Emigdio, Kern County, were first developed and have received most attention. Considerable ore from them has been treated in San Francisco, but they have not been worked recently. Inyo County has been reported to contain some very promising veins, whose remote situation is unfortunate. The total production of antimony in California in 1892 is estimated at eight tons.

Montana.—In 1889 antimony ore was mined near Thompson's Falls, and a small quantity was shipped to Philadelphia.

Nevada.—The only important antimony mines in the United States at the present time are situated in this State. The Big Creek Mining Company, Limited, operates the Beulah mine, near Austin, which is opened in a well-mineralized vein. A correspondent in Austin furnishes the following information concerning

it: "The mine has been developed in a systematic manner, and about 1100 linear feet of work have been done during the past year. A stope fully 120 ft. long, showing a breast of rich ore 2 ft. wide the whole distance, was opened in the summer and the outlook for the mine is excellent. Its output in 1892 was 600 tons (of 2000 lbs.), averaging 60% antimony and valued at $65 per ton at the mine." The Sutherland mines near Black Knob (about 15 miles from Lovelock's), shipped 200 tons of ore, averaging 55% antimony, to Starr & Mattheson of San Francisco. This mine has been opened by three tunnels, from 300 to 600 ft. in length, to a depth of 250 feet. The vein, which is said to show much ore already, is being developed energetically, and the management expects to ship from 600 to 800 tons of first-class ore during the first six months of 1893. A furnace was erected at the mines about a year ago, but proved unsuccessful, and the entire output of the year was shipped to San Francisco.

The total production of antimony ore in Nevada in 1892 was 800 short tons, valued at $50,000 at the mines. The equivalent in metallic antimony was 470 short tons, or 940,000 pounds.

New Brunswick.—Veins containing antimony have long been known in Prince William Parish, York County. The gangue is quartz and calcite. The properties were controlled by the Brunswick Antimony Company, of Boston, but of late years their production has ceased. The wall rocks are clay-slates and sandstone of Cambro-Silurian age.

Nova Scotia.—There are veins of stibnite at Rawdon, Hants County, and these were the sole source of the metal produced in Canada in 1889. A thickness of a little more than a foot of stibnite is reported. The amount produced has been steadily declining for some years, and in 1890 ceased entirely.

Mexico.—The deposit of senarmontite in Sonora, just south of the Arizona line and 30 miles from the Gulf of California, promised an excellent and rich ore at the surface. It contained considerable silver and was treated in San Francisco, but the supply grew less with depth and finally became too small for operating. The lodes are described as being from 4 to 20 ft. wide, in limestone and quartzite, but in a region that had experienced much igneous activity. They did not justify the original expectations.

Utah.—Deposits of stibnite are found on Coyote Creek, in Iron County, in the southwestern part of the Territory. They are peculiar, as they seem to form a thin bed or bed-vein, about eight inches thick, in soft calcareous sandstones. Attempts have been made to work them, but they have never succeeded.

Algiers.—Considerable antimony ore has been shipped from the towns of El Haminat and Semsa, in the Province of Constantine. Senarmontite occurs in the latter, while stibnite is the chief mineral at the former. The ore goes to Marseilles for treatment.

Asia Minor.—A considerable amount of antimony ore is shipped from the port of Smyrna to England.

Australia.—Both New South Wales and Victoria are important producers of antimony ore, and in both the stibnite frequently carries gold. In fact the difficulties which are met in treating these ores for the precious metal have received much attention. In the former colony veins are known in the Macleay district at Hargreaves Falls and Aberfoil. At Hill Grove a network of veins occurs in

metamorphosed Devonian strata near a dike of granite, and contains stibnite, while near Armadale a vein about one foot wide yields workable ores. In Victoria the towns of Sunbury and Whroo deserve mention. The statistics of both these colonies show that their production of antimony is an extremely variable quantity.

Austria-Hungary.—Austria and its tributary States, Bohemia and Hungary, send annually very considerable amounts of antimony ore to market. The Bohemian mines are on the Moldau River, and are opened on seven lodes in granite. They are less productive now than formerly. Other veins are known at Plan, in mica schist. The Province of Styria also contains mines. The chief productive region of Hungary is at Magurka, in the granite chain of Gumbir. The stibnite from Kremnitz is auriferous.

Borneo.—This island has been for many years one of the chief sources of antimony, but recently the older mines have become exhausted and the production has fallen off greatly. The mines are in the northern part of the island, in the independent State of Sarawak. They occur near the town of Bidi. The stibnite forms veins, but is also found as isolated masses in clay. By atmospheric degradation of the matrix these were sometimes left perched on pillars, like the well-known earth-pyramids, and ladders were required in order to reach them.

France.—The antimony mines in the department of Course, in Central France, have kept up their production with exceptional regularity for a very long period. Still, the amount is not sufficient for local demands, and a far larger supply is imported than is produced at home. Corsica should be mentioned in connection with France, for it has shipped as much as 800 tons of ore in a single year.

Germany.—Considerable antimony was obtained in former years from mines in the Rhine Provinces, but the statistics of Prussia for 1891 mention none whatever. There are also some small mines in Northern Bavaria, which produce an insignificant amount.

Italy.—The antimony mines in the Province of Tuscany are an important source. They occur near the town of Pereta, and furnish kermesite in large part. The ore goes to Marseilles for treatment.

Japan.—Notable amounts of antimony ores reach England from Japan. They are found in a number of localities, of which that on the island of Shikoku is especially known in Europe and America for its superb crystals of stibnite.

New Zealand.—Antimony occurs in many places in the north and middle islands, but the chief mining districts are between Endeavor Inlet and Port Gore. The principal development began in 1885.

Portugal.—This kingdom is the most important single source of the European States. The larger mines are near Oporto and Braganza. They are bed-veins of antimony and lead ores, and are auriferous. The wall rock is Silurian slate. The ores are dressed before shipping, so as to yield three grades : No. 1 averages 65% Sb; No. 2, 54.5% ; No. 3, 49%. Ores assaying from 35% to 45% will not pay for transportation, nor is any allowance made for gold and silver, although half an ounce of gold and one ounce of silver may be present. Other deposits occur in Southern Portugal, in the Province of Alemtejo.

Servia.—Important discoveries of antimony ores have been reported recently from Podrynia, and in this connection, although not in Servia, may be mentioned

the extensive enterprise that was started two years ago at Allchar, in Macedonia. The ores form irregular masses in dolomite and extend over a long distance.

Spain.—Within the last decade a rich mine has been developed in the Salamea de la Serena, in the Province of Badajoz. This mine and other mines in the same region ship from 500 to 600 tons yearly.

It is very evident after a review of the productive localities, both American and foreign, that the mines of antimony are extremely variable. Hardly any one district has been cited which has not experienced wide extremes of productiveness, and many which formerly were important are now abandoned. This is in large part due to the difficulties of treatment. The ore must be extremely pure to admit of profitable mining. As instanced under Portugal, which is comparatively near the English market (the great center), crude ores below 45% were not profitable in 1891. In purification by liquation, in the present stage of the metallurgy it seems practically impossible successfully to separate the stibnite from the gangue when the ores run below some such extreme limit as 30%. Such considerations are important in their bearings on the value of a new enterprise. Stibnite is poorly adapted to wet methods of dressing, because it is extremely brittle and is usually disseminated through hard quartz in fine needles or blades, which break up into slimes. The price of antimony changes greatly. The best grades varied in 1891 from 11⅝c. per pound as a minimum to 19c. as a maximum, and this would seriously affect the margin of profit in any enterprise. Hence while a vast quantity is imported, and the home (American) supply is far too small for the demand, some caution may well be exercised and all the relations appreciated in connection with new enterprises.

Characteristics of the Mineral.—The minerals containing antimony are: Stibnite (Sb_2S_3), Sb 71.8; senarmontite (Sb_2O_3), Sb 83.56; kermesite ($2Sb_2S_3.Sb_2O_3$), Sb 75.72; and a variety of others of no practical value for the metal. The important ore is stibnite. Senarmontite and kermesite occur in the upper parts of veins as oxidation products. All antimony minerals readily yield the white fumes of antimony oxide before the blowpipe, and hence afford a copious white coat on charcoal. Stibnite almost always occurs in needle-like or bladed crystals of a steel-gray color. The crystals are brittle, quite soft, and extremely fusible. They melt in the ordinary candle-flame. Senarmontite is white and very heavy; it frequently crystallizes in octahedra. Kermesite exhibits hair-like tufts or aggregates of a cherry-red color. In testing any antimonial mineral, the white fumes before the blowpipe are the best indication.

Metallurgy.—The metallurgy of antimony is theoretically simple, but the extreme volatility of the ores increases the difficulties. When mixed with gangue it is first purified, after hand-picking, by careful liquation, during which the sulphide drains away. This may then be fused with iron, some alkaline substance, and charcoal, so as to obtain the metal direct from the sulphide; or the sulphide may be first roasted to the oxide, which is reduced with charcoal and some alkaline flux. The button or lump of metal obtained in the bottom of the crucible is called the regulus, and the crust of fluxes, etc., which overlies it in reducing the oxide is called the crocus.

The English process of smelting antimony ores is here condensed from a paper

by Edward Rodger in the *Journal of the Society of Chemical Industry,* Jan. 30, 1892, and the *Engineering and Mining Journal,* March 12, 1892:

The ores for smelting by the English process must be free from lead and arsenic, neither of which metals can be eliminated. The ore is ground under edge runners and passed through a coarse screen, the largest pieces which are allowed to pass being about the size of hazel-nuts. After grinding, a sample is assayed to ascertain how much iron is required for reduction. The process of smelting consists in reducing the sulphide of antimony by means of metallic iron, the fusion taking place in crucibles which are heated in a very long reverberatory furnace. This furnace consists of a bed 54 ft. long, including the fireplaces, and 7 ft. 4 in. broad (inside size), covered by a low arch which springs almost from the surface of the ground, the bed itself being sunk below the level of the ground. It is heated by a fireplace at each end, drawing into a common flue in the middle of the floor of the furnace. The sides and top of the arch are covered with one-inch cast-iron plates, the whole anchored in the usual way.

The furnace is very little above the ground-level. It is, in fact, sunk into the ground, so that it is quite easy to step on to its iron-covered roof.

The crucibles are lowered into their places through circular holes, 14 in. diameter in the arch. There are 42 holes, 21 on a side. There are two 4-in. holes in the furnace roof at each end of the bed, used for removing clinker.

The pair of crucibles nearest the fireplaces at each end is kept for "starring" or refining the crude metal. The charge for each crucible consists of 42 lbs. of ground ore, 16 lbs. of wrought-iron scrap, 4 lbs. of common salt, and 1 lb. of skimmings from the next operation, or else the same weight of impure slag from a previous melting. These weights vary with every ore, but the above will be true for an ore of 52% Sb.

The iron scrap used must be wrought-iron, not cast-iron. Tinned scrap is preferred, the small trace of tin being generally believed to benefit the antimony. Part of the tinned scrap is beaten up into a round ball, large enough to fit the top of the crucible loosely. Such a ball weighs about 13 lbs., and one is used for each charge, the remaining iron required being added in the form of turnings or borings, mixed through the ore, along with the salt, in the weighing-scoop. The mixture of ore, salt, and iron is dropped into the crucible through an iron funnel, the lump of beaten scrap being thrown in last to form a kind of lid ; the furnace hole is then closed for about half an hour, when the crucible is again examined. In the meantime a fresh charge is weighed out ready for the crucible the moment it is empty. As the charge melts, the ball of iron on the top falls down and is gradually absorbed, the iron reducing the antimony to the metallic state, it being itself converted into sulphide. The salt assists the separation of the slag, and tends to promote the fusion of the silicious matters of the ore. The length of time required for fusion and decomposition varies with the position occupied by the crucible. As a rule, about four meltings are got from each crucible per 12 hours, so that, allowing for charging and occasional changing of crucibles, etc., a little less than three hours may be taken as an average ; the richer the ore the shorter the time required to melt it. Opposite to each crucible, except those used for the final refining, is placed a conical cast-iron mold, which stands close by the furnace side. It is large enough to hold the contents of the crucible and is furnished with a

cast-iron lid. The crucible is balanced on the edge of the furnace wall and the contents poured into the mold, which is at once covered with the lid; the crucible is examined, scraped out if need be, replaced, and at once recharged.

The mold has at the bottom a circular three-quarter-inch hole. The first portion which reaches the mold chills and prevents the escape of the remainder. The fused mass, when cool, is knocked out by a hammer and punch. When the mass is removed, the reduced antimony is knocked away from the slag, which should be quite clean enough to be thrown away. The metal obtained is known as "singles," and contains: Antimony, 91.63%; iron, 7.23%; sulphur, 0.82%; insoluble matter, 0.32%. An excess of iron is used to reduce the whole of the antimony in the ore, and the next operation consists in removing this by melting the "singles" with a small quantity of pure sulphide of antimony, the liquated sulphide being used for this purpose.

The charge for the second fusion consists of 84 lbs. of singles broken small, 7 lbs. to 8 lbs. of liquated sulphide of antimony, with 4 lbs of salt added as a flux. Sometimes kelp salt is used in place of ordinary salt in this fusion, and is found to be very suitable. The reaction in this fusion is similar to that in the last operation, the excess of iron in the metal reducing the pure sulphide of antimony to the metallic state, being itself converted into sulphide of iron. The fusion is closely watched, and great care taken that the metal and the sulphide of antimony shall mix thoroughly; but much stirring with iron tools should be avoided at this stage, as the object is to remove iron so far as possible. When stirring is required it is done as quickly as possible, in order to expose the iron stirrer as little as may be to the action of the sulphide of antimony. When fusion is complete, the mass is skimmed by means of a cast-iron ladle placed on a long shaft, and the metal is poured into molds identical with those used in the previous operation. The metal resulting from this melting is known as "star bowls," and each fusion yields a lump of about 80 lbs. The skimmings go to the first operation. An analysis of this second metal showed: Antimony, 99.53%; iron, 0.18%; sulphur, 0.16%—total, 99.87%. The surface of the crystals of this metal is covered with tiny bright specks, which are a certain sign of the presence of sulphur; this appearance is known as "flouring," metal showing these specks being said to be "floured." As in the first melting it is necessary to add an excess of iron in order to remove all the antimony, so in this case it is necessary to add an excess of sulphide of antimony in order to remove all the iron, and hence the presence of sulphur in the antimony obtained. In order to remove this sulphur, and finally to purify the metal, another melting is required; and the custom of the trade being that antimony shall be sold in flat ingots, each "starred" or crystallized on the upper surface, it is necessary to take precautions so as to obtain this "star" or crystallized appearance, by means of which the buyer judges of the purity of the metal. These two results are achieved by melting the metal along with a peculiar flux known as "antimony flux," a body not easily prepared and one which is often difficult to obtain at first, but, having obtained it, it is easily kept in order. The process of making this flux is a rule-of-thumb one and is carried out something in this way: Three parts of ordinary American potash are melted in a crucible and two parts of ground liquated sulphide of antimony mixed in. When the mixture is complete and the fusion quiet, the mass is poured out and

tried on a small scale in order to see whether it yields a good "star;" if it does, the ingot of metal obtained is broken and the metal examined in order to judge whether it is free from sulphur. If free, then the flux is considered satisfactory and may be put in use; but otherwise the flux is remelted and more of one ingredient or the other is added as experience dictates.

The process of refining and restarring the star-bowls is as follows: The lumps of metal when cold are removed from the mold and thoroughly cleaned from the adhering skin of slag by chipping with sharp hammers, this part of the work being sometimes done by women, who become very expert in rapidly and completely removing every trace of slag. Unless this cleaning process is carefully carried out it is hopeless to attempt to obtain a good star on the finished metal. The chippings are, of course, collected and returned to the second melting. The star-bowls, having been cleaned, are broken small, and a charge weighed out for refining. The charge used is 84 lbs. of star-bowls and a sufficiency of the antimony flux. Enough flux is added to surround the ingots completely, and for this less or more is needed, according to the shape and thickness of the ingots: for ingots of the ordinary shape about eight pounds are required. The melting takes place in the crucibles next the fireplaces—that is to say, in those which are hottest and in which the fusion will be most rapid. The charge of metal is thrown into the crucible and narrowly watched, and whenever it begins to melt the flux is added. As soon as the fusion appears to be complete the furnaceman stirs the mixture once round only with an iron rod, and the charge is at once poured out. The ingot molds are placed side by side, having between them a wedge-shaped frame of cast-iron, called a "saddle," the edge of which points upward, and upon which the charge is poured, when the stream divides, one half finding its way into each mold. These molds are left to cook undisturbed, and as they cool the flux which covers the surface cracks, and when cold can be easily knocked off. The flux is used over and over again, a piece of carbonate of potash being thrown into each fusion when old flux is used. In this way it will be seen that the flux keeps on increasing as a little potash is added and a little sulphur and antimony are picked up at each fusion. The ingots must be completely surrounded by flux; there must be a thin layer of it between the mold and the metal, and also the whole surface of the ingot must be covered to the depth of a quarter of an inch. Under the circumstances the metal should always give a good star and preserve a good color. The traces of flux which adhere are removed by washing in warm water with the assistance of a little sharp sand, water by itself being insufficient to remove the flux, which is practically insoluble in water.

The personnel of such a furnace consists of about 36 men and 3 women, this total being made up as follows: 2 firemen, one each fire, day and night, 4; 8 furnacemen, 4 on each side, day and night, 16; 2 men cleaning metal, day and night, 4; 2 men breaking metal, day and night, 4; 1 man weighing charges, day and night, 2—total, 30. On day shift only there are: 3 men laboring, grinding ore, etc., 3; 1 smith, repairing tools, etc., 1; packing and washing, 3 women; and 1 engine and boiler man, 1—total, 38. Of course this does not include the making of crucibles, but, generally speaking, one crucible-maker and one laborer can make enough crucibles, working during the day only, to keep the furnace going. The coals used, including those used for firing the kilns, amount to about 22 tons per

week, or a little more than a ton and a half each shift. About 11 crucibles are used per ton of refined metal produced, but this might be reduced by careful working. The yield of finished metal from such a furnace, working a 52% ore, is about 14½ tons per week.

A great deal of volatilization takes place from the melted metal in the pots, and the fume thus produced is condensed in the flues of the furnace, which are built for that purpose in a winding manner, passing backward and forward under the floor of the crucible drying stoves, so as to dry the pots at the same time that the fume is condensed. The total amount of fume varies very much: the richer the ore the less fume there is in proportion to the antimony produced, although the absolute amount is greater than when a poorer ore is worked. About 10% of the total antimony contained in the ore is volatilized, and of this the greater part is condensed in the flues. The fume is whitish, heavy, and rather crystalline, in appearance not very unlike white arsenic. It contains about 70% to 72½% of metallic antimony. The smelting of this fume is conducted as follows: A test experiment is made in order to ascertain the amount of carbon in the form of coke or anthracite necessary to reduce all the antimony present in the fume. This having been found, the fume is mixed by grinding under edge runners with the proper quantity of carbonaceous matter, and of the mixture so produced a few pounds' weight is added to each charge of ore and iron when melting for singles. As the gases given off in the process are apt to cause the mixture in the pots to overflow, the "boiling ore," as the workmen term the mixture of fume and coke, is therefore looked upon by them with great disfavor; but beyond the mechanical difficulties, there is no trouble whatever in smelting the fume. The flues require cleaning out at intervals, sometimes once every two or three months.

The ingots, which are known in the trade as "French metal," after being wrapped in straw, are packed in kegs holding about 6 cwt. net.

In the subsequent citations of literature, an important paper by R. Helmhacker is mentioned which sets forth many valuable points in the chemistry of the metallurgical processes and their attendant reactions.

Cakes or ingots of antimony (regulus) are crystalline and brittle. They exhibit rude outlines of crystals which suggest ferns and stars; hence the metal itself is called "star antimony." The value of any sample of antimony is judged, not by analysis, but by its appearance, and a good sample of metal should exhibit the following characteristics: The star should be bold and defined, standing well up on the metal, the edges of the ridges sharp and straight; the metal itself should be lustrous and white, not dull and leaden-looking. Lastly, on breaking the ingot, the crystals should be large and their surfaces free from specks, which are a sign of sulphur in the metal, a most undesirable impurity. On this last point, perhaps more than on any other, depends the value placed upon the sample under consideration.

The principal impurities are lead, arsenic, iron, and sulphur. In alloys containing lead and antimony, however, lead may not be so objectionable, the disadvantage being that chemical analysis is needed to indicate the proportions to be used.

Uses.—Antimony is most largely employed in the form of alloys with other metals. To soft metals like lead it gives stiffness and hardness, as in type-metal,

britannia-metal, etc. It likewise is used in babbitt-metal for bearings, and for many similar uses. In copper, however, it is one of the most deleterious and dreaded of impurities. The native sulphide has been found useful in vulcanizing rubber. Much antimony in the shape of alloys reaches the market as a by-product in the metallurgy of base bullion. Some silver-lead mines, of which the Horn Silver at Frisco, Utah, is an example, furnish a very hard grade of silver-lead, and when this is skimmed in the softening process, preliminary to zinc-desilverization, the skimmings contain zinc, antimony, arsenic, copper, etc., and are often sold direct for alloys.

Market.—England (London) is the great market for foreign ores. There are four principal smelters—Cookson & Co., at Newcastle-on-Tyne, who make the best grade; Hallett & Fry, Johnson & Matthey, and Pontifex & Wood, all of London. Sales are usually made through brokers and by samples. Oxide ores are less valuable than the sulphide. Henry Bath & Sons, London, publish a bi-monthly circular giving prices of ores, liquated sulphide, and regulus. The French smelters are as follows: E. Beau, at Alais; E. Chatillon and V. Giraud, at Brionde.

PRODUCTION OF ANTIMONY IN THE UNITED STATES.*

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1880	100,000	$10,000	1887	150,000	$15,000
1881	100,000	10,000	1888	200,000	20,000
1882	120,000	12,000	1889	230,000	28,000
1883	120,000	12,000	1890	257,768	40,756
1884	120,000	12,000	1891	910,000	45,500
1885	100,000	10,000	1892	956,000	51,600
1886	70,000	7,000			

* The figures for the years previous to 1891 are from *Mineral Resources of the United States*, 1889 and 1890. The figures for 1891 and 1892 are the metallic contents of ore produced, most of which was shipped to England for treatment. Values are estimated on the basis of prices paid for ores and are consequently proportionately less than in previous years.

IMPORTS OF ANTIMONY INTO THE UNITED STATES.

Year.*	Crude and Regulus.		Ore.		Total Value.
	Pounds.	Value.	Pounds.	Value.	
1867	....	$63,919	....	....	$63,919
1868	1,033,336	83,822	....	....	83,822
1869	1,345,921	129,318	....	....	129,318
1870	1,227,429	164,179	....	....	164,179
1871	1,015,039	148,264	....	$2,364	150,628
1872	1,933,306	237,536	....	3,031	240,567
1873	1,166.321	184,498	....	2,941	187,439
1874	1,253,814	148,409	....	203	148,612
1875	1,238.223	131,360	6,460	609	131,969
1876	946,809	119,441	8.321	700	120,141
1877	1,115,124	135,317	20,001	2,314	137,631
1878	1,256,624	130.950	20,351	1,259	132,209
1879	1,380,212	143,099	34,542	2,341	145,440
1880	2,019,389	265,773	25,150	2,349	268,122
1881	1,808,945	253.054	841,730	18,199	271,253
1882	2,525,838	294,234	1,114,699	18,019	312,253
1883	3,064,050	286,892	697,244	11,254	298,146
1884	1,779,337	150,435	231,360	6,489	156,924
1885	2,579,840	207,215	215,913	7,497	214,712
1886	2,997,985	202.563	218.366	9,761	212,324
1887	2,553,284	169,747	362,761	8,785	178,532
1888	2,814,044	248,015	68,040	2,178	250,193
1889	2,676,130	304,711	146,309	5,568	310,279
1890	3,315,659	411,960	611,140	29,878	441,838
1891	3,258,701	388,850	1,433,531	36,232	425,082
1892†	3,018,149	306,542	175,706	7,367	313,909

* Fiscal years previous to 1885; calendar years subsequently. † Nine months.

Recent Bibliography.—W. P. Blake, *Mineral Resources of the United States*, 1883–84, p. 641. P. L. Burthe in the *Annales des Mines*, 1892, vol. ii. p. 163. On Arkansas mines: T. B. Comstock, *Annual Report of the State Geologist of Arkansas*, 1888, vol. i. pp. 136, 216. F. P. Dunnington on the mineralogy, *American Association for the Advancement of Science*, 1877; J. W. Mallet, *Chemical News*, No. 533; C. P. Williams, *American Institute of Mining Engineers*, iii. 150; and C. E. Wait, *ibid.*, viii. 42. W. P. Blake, *United States Pacific Railroad Exploration and Survey*, v. 291; H. G. Hanks, *Report of the California State Mineralogist*, 1884, and William Irelan, Jr., 1890. On Sonora: E. T. Cox, *American Journal of Science*, III., vol. xx. p. 451; James Douglas, *Engineering and Mining Journal*, May 21, 1881, p. 350. On New Brunswick: L. W. Bailey, *American Journal of Science*, II., vol. xxxv. p. 150, and *Geology of New Brunswick*, 1865. On Utah: D. B. Huntley, *Tenth Census*, vol. xiii. p. 463. On the metallurgy of antimony: a good paper by R. Helmhacker, *Studien über die Antimonhütten-Processe* in *Berg-u. Huet. Zeitung*, 1883, pp. 1, 23, 44, 145, 172, 191. On the English process, Edward Rodger, as quoted above, from the *Journal of the Society of Chemical Industry*, Jan. 30, 1892, and the *Engineering and Mining Journal*, March 12, 1892.

The Antimony Market in 1892.

Although the consumption in 1892 was larger than in 1891, the market during the year was rather depressed, prices being considerably below the rather-high figures ruling in the previous twelve months. However, the price of this metal is principally dependent on the available supplies, and if these are abundant a low level is maintained, while if they are scarce the reverse is the case. The principal source of supply is now, as formerly, Japan; and we even understand that in Portugal, one of the producing countries which might be called "outside," the output for 1892 shows a decrease as compared with that for 1891. Small consignments of crude ore are sometimes sent to England from Mexico, but, we understand, they almost always cause a loss to the shippers. No progress in the smelting of star antimony was made in this country during the year, though there are good prospects that at an early date the production of antimony will become an important industry here.

The year commenced with Cookson's antimony obtainable at a little below 16c., L. X. at 15, and Hallett's at 12¼c., but as early as February there was a decline of fully 1c. a pound on all. From then onward, month by month, prices slowly gave way, quotations in April being 14¼c., 12¼c., and 10⅞c., respectively; and although a somewhat better feeling was evinced in May and June, the retrograde movement became more and more pronounced in July, when the prices were 13¼c., 12¼c., and 10⅝c., while in August they were 12c., 11½c., and 10¾c. September was the month of the lowest values, Cookson's then being freely offered at 11½@11¾c, with L. X. held firmly at from 11@11¼c., Hallett's being obtainable at 10@10¼c. At these figures consumers closed large contracts, and prices in England stiffening, quotations here hardened, and Cookson's advanced to 11¾@12c., L. X. remaining steady at 11@11¼c., and Hallett's going up to 10⅝@11¾c.

Late in November there was a perceptible weakening, and by the early part of December prices had dropped to 11½@11¾c. for Cookson's, 11c. for L. X., and 10½c. for Hallett's, while at the close of the year they were still lower, at 11¼@11½c., 11c., and 10¼@10⅝c., respectively.

ASBESTOS.

Asbestos of inferior quality is found in a number of localities in the United States, but these are for the most part of no more than mineralogical interest, and have never become important producers. The total amount of asbestos mined in the United States in 1889 was but 30 tons, valued at $1800; while in 1890 the product was only 71 tons, valued at $4260, the production each year being limited to California. In 1891 the output was 66 tons, valued at $3960 and the product of 1892 has probably been equally insignificant. The American mineral is adapted only for grinding, for paints and cements, for boiler and steam-pipe covering, etc. The chief source of fibrous asbestos, suitable for weaving formerly was Italy; but since 1879 the mines in the Province of Quebec, Canada, have become the most important producers, and the American market is principally supplied by them. The Canadian mineral occurs in veins in serpentine, with the fibers perpendicular to the walls. The form of asbestos best adapted for the manufacture of fire-proof textile materials is chrysotile, a variety of serpentine, which may be distinguished from asbestos proper by the fact that it yields water when heated in a glass tube. The fibers of asbestos are short and brittle, while those of chrysotile are flexible, slightly elastic, and of great tensile strength. During the past year asbestos has been discovered in Gallatin County, Montana, at a point about 32 miles southwest of Bozeman, and a mine has been opened on the vein by the Gallatin Asbestos Co. The quality of the mineral taken out is said to be inferior to that of the Canadian article, but still is capable of withstanding a severe fire-test. Considerable attention has also been paid to newly discovered deposits of asbestos on Casper Mountain, in Natrona County, Wyoming, where promising veins are said to occur in serpentine dikes extending through a considerable area. Numerous claims have been located, and some desultory development work has been done, but no mineral has been shipped as yet. The asbestos found there is claimed to be of good quality, although inferior to the Canadian. The following table gives the imports of asbestos into the United States from 1869 to the past year, and the production since 1880:

UNITED STATES: PRODUCTION AND IMPORTS OF ASBESTOS.

Year.*	Imports.			Production.		Year.*	Imports.			Production.	
	Total.	Unmanufactured.	Manufactured.	Quantity, Tons of 2,000 lbs.	Value.		Total.	Unmanufactured.	Manufactured.	Quantity, Tons of 2,000 lbs.	Value.
1869...	$310	....	$310	....	......	1881...	$27,786	$27,717	$69	200	$7,000
1870...	7	....	7	....	......	1882....	15,739	15,235	504	1,200	36,000
1871...	12	....	12	....	......	1883...	24,612	24,369	243	1,000	30,000
1872...	......	....	....	....	......	1884..	49,940	48,755	1,185	1,000	30,000
1873...	18	$18	....	....	......	1885....	73,643	73,026	617	300	9,000
1874...	152	152	....	....	......	1886...	135,125	134,193	932	200	6,000
1875...	5,783	4,706	1,077	....	......	1887....	140,845	140,264	581	150	4,500
1876...	5,881	5,485	396	....	......	1888....	176,710	168,584	8,126	100	3,000
1877...	3,221	1,671	1,550	....	......	1889....	263,393	254,239	9,154	30	1,800
1878.	3,908	3,536	372	....	.....	1890..	257,879	252,557	5,342	71	4,560
1879...	7,828	3,204	4,624	....	......	1891....	366,426	355,314	11,112	66	3,960
1880.	9,736	9,736	....	150	$4,312	1892..	† 99,539	† 95,495	† 4,044	100	5,000

* Prior to 1885 the imports are stated for fiscal years ending June 30; subsequently for calendar years. The figures of production are all for calendar years. † Six months.

NOTE.—The value of the asbestos exported from the United States between 1869 and 1892 is as follows: 1879, $2,335; 1880, $7,848; 1881, $30,785; 1882, $18,923; 1883, $17,865; 1884, $30,846; 1885, $36,068; 1886, $29,303; 1887, $10,191; 1888, $2,910. These figures are all for fiscal years ending June 30. 1889, $120; 1891, $17,847; 1892 (six months), $1,250.

ASBESTOS IN CANADA.

BY J. T. DONALD.

Canada and Italy furnish the world's supply of asbestos. The Italian mineral was first on the market, but now Canada is by far the most important producer. The superiority of the Canadian fiber is clearly indicated by the fact that in 1889 the United Asbestos Co., an organization which largely controls the Italian mines, purchased as a going concern a valuable mine in the Canadian field and has worked it vigorously ever since; and by the further fact that Canadian asbestos is to-day sold in Italy itself almost at the pit's mouth.

The Italian asbestos, which is of very long fiber, occurs in such shape that it is difficult to handle it with machinery. The Canadian article is in much shorter fibers, yet long enough for most, if not all, requirements, and has the immense advantage of being easily worked into the various forms adopted by manufacturers.

The asbestos of commerce is practically a finely fibrous form of serpentine; that is to say, it is essentially a hydrated silicate of magnesia, as is shown by the following results of analyses recently made in the writer's laboratory. These results also show clearly that in composition Canadian fiber does not differ materially from the Italian.

	I.	II.	III.
Silica	40.30%	40.57%	40.52%
Magnesia	43.37	41.50	42.05
Ferrous oxide	.87	2.81	1.97
Alumina	2.27	.90	2.10
Water	13.72	13.55	13.46

I. is Italian as found in commerce, II. is Canadian of the very finest quality from the Thetford-Black Lake district, III. is from Templeton in the Ottawa district, where search for asbestos is being made in the Laurentian serpentine.

Every deposit of serpentine is a possible repository of asbestos. Profitable asbestos-mining, however, is at present confined to a small area in the great serpentine belt of the Province of Quebec, that lies to the south of the St. Lawrence River. The great majority of the mines are clustered around the villages of Thetford and Black Lake, stations on the Quebec Central Railway, which connects the cities of Sherbrooke and Quebec.

Asbestos-mining is a recent industry in Canada, dating back only as far as 1878, when the total production amounted to less than one hundred tons, which it was not easy to sell. Ten years later the industry had become an exceedingly important one, and the demand for the mineral was in excess of the supply.

In 1889 the finest quality or "firsts" found ready sale at from $80 to $120 per ton, "seconds" brought from $50 to $70 per ton, whilst "thirds" were valued at $25 to $35 per ton, and "waste" at $10 to 15 per ton. The range in price of the different grades is due to the fact that there is no uniform system of grading, but each miner uses his own discretion, and consequently it happens that "seconds" of one mine may be but slightly if at all inferior to the "firsts" of another mine. In the beginning of 1890 what may be termed an asbestos boom set in; the price went up by leaps and bounds until in the latter part of 1890 and the beginning of 1891 first quality sold for as much as $250 per ton and even more, whilst other grades brought proportionately high figures.

This rapid advance in price was due to several causes. In the first place, the intrinsic value of the mineral was becoming better known, and certain speculators recognizing this, purchased and held large quantities—endeavored, in fact, to corner the market. Then, next, American manufacturers, who have always been large purchasers of the Canadian mineral, were eagerly competing for the trade in manufactured goods, and thinking the output of the Canadian mines was not more than commensurate with the present and early future demands of the trade, vied with each other in bidding for any crude mineral that was offered. The era of high prices did not last long. Soon the speculators began to unload and broke the market. American manufacturers formed a combination, and ceased to bid against one another in purchasing ore; indeed, having a stock on hand and realizing the condition of the ore market, they were unwilling to buy at all. In a word, the supply of crude asbestos had, for the first time since the inception of the industry, overtaken, and even run beyond, the demand. The result was a heavy fall in prices, and asbestos-*mining* received a shock from which it has as yet scarcely recovered.

The history of the asbestos industry as a whole has, however, been one of steady progress; the uses of the mineral are steadily increasing, and there is no doubt that the asbestos outlook is very hopeful. The crisis just referred to will have the effect of placing the mining of this mineral on a proper business basis, and the only real change from the past is that henceforth the miners will have to carry a stock of ore, instead of the manufacturers. The effect of this change will be to drive out of the business small operators who were able to work when they could sell their output in advance, and to place upon the market good properties, the owners of which have not the capital necessary to work them under the changed condition of affairs.

Large manufacturers of asbestos abroad are aware of this latter result, and as a consequence there is a quiet but persistent demand for such properties.

The prospect for the future, then, is, that asbestos-mining will be carried on by large companies with ample capital, and well able to hold their own with any ordinary combination of manufacturers. It may then be reasonably expected that both the mining and manufacturing of this article will be so conducted as to yield a reasonable profit to those engaged in both branches of the industry.

As furnishing a clue to the probable prices of the mineral under these circumstances, it is worthy of note that a competent authority has recently calculated that the actual cost of producing a ton of asbestos of all grades is $55.75 (this is for the mines as a whole); and adding to the actual cost interest at 10% on the capital invested, he shows that in order to make his business a paying one the miner must receive on an average $80 per ton for his ore. This means, say, $150 to $160 for "firsts," $110 to $125 for "seconds," and for "thirds" $50 to $75 per ton.

Thirteen incorporated companies and a number of private concerns are engaged in asbestos-mining in Canada. They have invested a sum of nearly $2,250,000, of which $355,000 represents plant. About 2000 men and boys are employed. The following are the official figures of production of asbestos from 1879 to 1890:

Year.	Tons.	Value.	Year.	Tons.	Value.
1879	300	$19,005	1886	3,458	$206,251
1880	380	24,700	1887	4,619	226,976
1881	540	35,100	1888	4,404	255,007
1882	818	52,650	1889	6,113	426,554
1883	955	68,750	1890	9,860	1,260,240
1884	1,141	75,097	1891	9,000	1,000,000
1885	2,440	142,441	1892*	6,000	650,000

* Estimated by L. A. Klein.

Tons of 2,000 lbs.

It is difficult to obtain accurate figures for the production of 1891 and 1892, as producers are unwilling to say what quantity they have in store, but it is well known that 1892 has fallen far below 1891 in asbestos production.

Notes on the Asbestos Industry of Canada.

By L. A. Klein.

Asbestos mining consists (1) of the mining operations proper, such as the drilling, blasting, removing of the broken rock out of the pits to the dumps, hand in hand with the gathering of the asbestos mineral and transport of the same to the dressing establishments or cobbing shed. The average cost of this in Quebec may be set at about 3½c. per ton of rock handled for drilling, 3c. for blasting, and 25c. for removing of rock and gathering asbestos in the pits. The cost of production of one ton of asbestos will naturally depend upon the number of tons of rock to be removed per ton of asbestos, or upon the richness of each individual mine. Few places show ground as rich as 50 tons of rock per ton of asbestos, while others run as high as 150 and more. One per cent of asbestos in the works, with a fair proportion of high grades (that is, long fiber), is considered a profitable mine at the present price of the product. (2) Dressing, or cobbing;

i.e., the separating of the asbestos fiber from the adhering rock and grading it in different qualities, followed by packing, transport to railroad, loading, shipping, and marketing. Of course the cost of cobbing varies considerably according to the quality of the material. While some stuff will break from the stone very easily, other kinds require considerable labor. Some occasionally may be contracted for at $3 per ton (this, however, never includes the manipulation of cobbing stones), while other material may cost as high as $15 or $18, and more. Including the breaking of the cobbing stones, $7 may be estimated as the average cost of cobbing of asbestos for a ton of marketable material. Bags and bagging, with transport to railway and loading, may be set at an average cost of $2 per ton; supplies, such as fuel, steel, iron, timber, and other material and repairs, $5.50 per ton; general business expenses, management, insurance, offices, and marketing product, $6 per ton; to which is to be added wear and tear of machinery and depreciation, and interest on capital.

It is, of course, very difficult to give figures of cost of different things pertaining to the asbestos-mining industry for a whole district, a number of mines working sometimes under entirely different circumstances, and the foregoing estimate is given with this fact in mind.

The machinery employed consists of air-compressors, air or steam drills, hoisting and winding engines, boom and cable derricks, and in some instances Blake crushers, rolls, and other crushing and fiberizing machinery to which cleaning and grading devices are attached. Forty boilers with a capacity of 1825 horse-power; 7 compressors with 44 drill capacity; 44 drills, of which 7 are run by steam, the remainder by compressed air; 18 double and 24 single drum hoisting and winding engines, or a total of 60 drums, with the corresponding amount of derricks and a number of pumps, make up the total of the machinery in use; and the whole, including engine-houses, mills, dressing and store sheds and dwellings, represents a value of about $355,000.

There is still a certain amount of hand work and horse-power hoisting exercised in asbestos-mining, but this nowadays is almost entirely confined to prospecting and developing work.

The most prominent companies operating asbestos mines are the following: American Asbestos Company, Limited, Black Lake; Anglo-Canadian Asbestos Company, Limited, Black Lake; Beaver Asbestos Company, Thetford mines; Bell's Asbestos Company, Limited, Thetford; Glasgow and Montreal Asbestos Company, Limited, Black Lake; Jeffrey Asbestos Mines, Danville (private); Johnson's Company, Thetford; King Brothers, Thetford (private); Thetford Asbestos Company, Thetford; and United Asbestos Company, Limited, Black Lake.

The height of production as well as value of product was reached in 1890, followed by a slight falling off in 1891 and a decided decrease in 1892. This decrease is not due to an inferior quality of working ground, but has been brought about by the endeavor of the mine proprietors to re-establish with least delay proper relations between demand and production, which had been disturbed by the enormous increase of the previous years. Up to that time the mines were hardly able to supply the demand from manufacturers both here and abroad, which would indicate that the consumption was about 6000 tons in 1889, and that the yearly increase since 1884 has been from 1000 to 1700 tons. There are very

good reasons to believe that the asbestos-manufacturing industry has kept on increasing at about the same rate; and if this is so the over-production of the years 1890 and 1891 will be used up before the season of 1893 opens, and will enable all the mines to work during the coming year at nearly full capacity—at least during the summer and autumn months.

As to the future of asbestos-mining in Quebec, I consider it very bright in view of the fact that, notwithstanding occasional rumors of new discoveries in various parts of the world, thus far no new area of any practical value has been found; moreover, all the prominent mines of Quebec are fully equipped, and in 1890 did their utmost to raise the production to about 10,000 tons, and probably it will be difficult to make a further increase of more than 1000 tons, while the manufacturing business is gaining ground every day.

Asbestos is used for packing purposes either in the shape of yarn as ropes for packing valves, cocks, piston-rods, throttle-valves, etc., or in the shape of millboards for joint packing of steam-pipes, cylinder, and steam-chest covers, etc.

Even in the face of a temporary overproduction of crude asbestos and the necessity of keeping a part of it stored at the mines, prices kept firm. We have quoted during the past year about $200 per ton (2000 lbs.) for No. 1, $100 for No. 2, and $50 for No. 3, free on board at the mines, with due allowance for very careful or inferior grading. No. 1 represents the longest and finest fiber, from about three fourths of an inch up, without discoloration, and is used chiefly for spinning purposes. No. 2 is composed of an inferior grade of long fiber, being either harsh and less flexible or discolored (principally from iron), and short but clear,—i.e., unbroken fiber from about half an inch up,—and is principally used for inferior qualities of wick-packings and for fillers. No. 3 consists of pieces containing still shorter fiber, to a large extent intersected with serpentine and iron, and is, when cleaned from foreign substances, principally used in the manufacture of paper, card-board, etc.

The markets of crude asbestos until recently have been divided strictly into two classes—Europe using, we may say, practically all the No. 1 and a part of No. 2 crude, while America consumed all the No. 3 and the remainder of No. 2. These conditions have changed rapidly in the last two years. Europe has consumed lately a considerable amount of the lower grades, while as much No. 1 is now used in America as in Europe. The principal markets on this continent are New York and Erie, Pa.; on the other side of the Atlantic, London, Liverpool, Frankfort, Rotterdam, and Hamburg. Last year's shipments amounted to but 371 carloads (about 15 tons per car), owing to the fact of considerable stocks being held at the beginning of the season by manufacturers and brokers. Freight rates were comparatively high during the whole season, and amounted to 28c. per 100 lbs. to New York, 32.86@36.08c. to London and Liverpool, and 42.52@44.23c. to Rotterdam.

ASPHALTUM.

Asphaltum and bituminous rock are found in California, Utah, northwestern Colorado, Kentucky, and Texas. The most important deposits are in California and Utah, and nearly all the mineral produced in the United States is derived from those sources, a small amount being mined in Kentucky and Ohio.

California.—Asphaltum and bituminous rock occur in Ventura, San Luis Obispo, Santa Cruz, and Santa Barbara counties, all of which are in the southern part of the State. The product of Ventura County is of the highest grade, and a portion of it is refined and used as a protective coating for wharf timbers, wooden conduits, etc. The other counties produce bituminous rock, or asphaltic sandstone, exclusively, which is used as a paving material in several cities of California. The streets of Los Angeles are laid chiefly with domestic asphalt, which has given very good results, but the cost of transportation restricts the use of this material to the cities of the Pacific coast. Considerable quantities of brea, or liquid asphalt, are produced in Ventura County. It is used as a protective covering for iron-work liable to rust.

Colorado.—Deposits of asphaltum similar to those of Utah occur in the northwestern part of this State, but they have not yet been opened extensively. During the past year the American Asphalt Company, of Grand Junction, has commenced operations in this region.

Kentucky.—There are deposits of bituminous rock in Hardin and Grayson counties, similar in character to those of Santa Cruz and San Luis Obispo counties in California. It is used for street-paving, warehouse floors, etc.

Utah.—Valuable deposits of bituminous rock, gilsonite (an exceptionally pure form of asphaltum), and ozokerite (mineral wax) are mined in this Territory. Gilsonite, or uintaite, is shipped by the Gilson Asphaltum Company from its mines near Fort Duchesne, in the Uintah Reservation ; the Wasatch Asphaltum Company produces an asphaltic limestone, used for street-paving, from mines in Spanish Fork Cañon; while lesser amounts of these minerals are mined by the Utah Asphaltum Company near Ashley, and by the North American Asphalt Company and the Cosmos Company. The gilsonite of Utah finds a ready market in St. Louis, where it is used as a varnish, bringing $50 per ton at the shipping point, Price, Utah. The bituminous rock is used as paving material in various cities of the West, but the high transportation rates make competition with the Trinidad asphaltum impossible east of the Mississippi River. The shipments of gilsonite from Price, Utah, in 1892 amounted to 1485 tons, valued at $74,250.

Texas.—A deposit of bituminous limestone, said to be extensive, has been discovered in Western Texas, near the line of the Southern Pacific Railway, and a corporation, the Litho-Carbon Company, has been organized to work it. This material on refining gives a very good grade of asphaltum, suitable for the manufacture of varnishes. Deposits of bituminous rock occur in the northern part of the State.

UNITED STATES: PRODUCTION AND IMPORTS OF ASPHALTUM.

Year.	Production.		Imports.		Year.	Production.		Imports.	
	Short Tons.	Value.	Short Tons.	Value.		Short Tons.	Value.	Short Tons.	Value.
1867	....	....	....	$6,268	1880	444	$4.440	11,830	$87,889
1868	....	....	185	5,632	1881	2,000	8,000	12,883	95,410
1869	....	....	203	10,559	1882	3,000	10,500	15,015	102,698
1870	....	....	488	13,072	1883	3,000	10,500	33,116	149,999
1871	....	....	1,301	14,760	1884	3,000	10,500	36,078	145,571
1872	....	....	1,474	35,553	1885	3,000	10,500	18,603	88,062
1873	....	....	2,314	38,298	1886	3,500	14,000	32,565	108,528
1874	....	....	1,183	17,710	1887	4,000	16,000	31,108	97,377
1875	....	....	1,171	26,006	1888	53,800	331,500	36,615	84,060
1876	....	....	807	23,818	1889	51,735	171,537	61,705	138,885
1877	....	....	4,532	36,550	1890	40,841	190,416	73,345	223,891
1878	....	....	5,476	35,932	1891	45,054	242,264	114,725	229,350
1879	....	....	8,084	39,635	1892	54,985	291,250	109,582	336,017

NOTE.—The figures of production 1880-91 are from *Mineral Resources of the United States*, 1889-90. The imports are stated for fiscal years ending June 30 until 1885, and subsequently for calendar years.

TRINIDAD ASPHALTUM.

Most of the asphaltum used in the United States is imported from the island of Trinidad, where occurs the famous pitch lake which has been described repeatedly. For the latest information concerning it the reader is referred to an article in *United States Consular Reports*, October, 1892, pp. 169–239. The lake asphalt of this island is entirely controlled by the Trinidad Asphalt Company, which reserves to itself a monopoly of the shipments to the United States, but sells freely for export to Europe at 28s. 6d. ($6.84), free on board, for crude, and 58s. 6d. ($14.04), free on board, for *épurée.* The cost of land asphalt, laid down in New York, is thus stated by Consul Pierce in the report already referred to: Price of pitch in the ground, $4; digging, overlooking, and cleaning, $0.50; carting, $0.40; loading lighters and loading ship, $0.30; lighterage from shore to ship, $0.50; contractor's profits, mercantile commission, and all other expenses and losses, $1.10; export duty, $1.20; freight and insurance to New York, $2.25 —total, $10.25.

EXPORTS OF ASPHALT FROM TRINIDAD, 1885–91.

(From Custom-house records.)

Year.	Pure.			Crude.		
	United States.	Other Countries.*	Total.	United States.	Other Countries.*	Total.
	Tons.†	Tons.†	Tons.†	Tons †	Tons †	Tons.†
1885	184	6,547	6,731	15,573	12,932	28,505
1886	....	5,416	5,416	25,720	4,505	30,255
1887	2,246	5,780	8,026	23,937	11,135	35,072
1888	2,494	8,731	11,235	31,424	9,367	40,791
1889	2,546	9,013	11,559	56,503	10,062	66,565
1890	1,441	9,199	10,640	42,990	25,211	68,201
1891	951	9,080	10,031	75,025	10,933	85,958

* Chiefly European. † Long tons, 2240 lbs.

EXPORTS OF ASPHALTUM FROM TRINIDAD.
(From Harbor-master's Records.)

Year.	America, Tons.*	Europe, Tons.*	Total Tons.*	Year.	America, Tons.*	Europe, Tons *	Total Tons.*
1867	700	3,027	3,727	1877	1,441	11,576	13,017
1868	200	1,325	1,525	1878	5,860	9,926	15,786
1869	....	5,297	5,297	1879	9,078	13,633	22,711
1870	2,953	5,857	8,810	1880	7,178	15,614	22,792
1871	828	3,222	4,050	1881	8,523	17,753	26,276
1872	2,144	9,854	11,998	1882	15,075	14,878	29,953
1873	746	6,913	7,659	1883	24,781	15,025	39,806
1874	711	9,204	9,915	1884	19,685	17,913	37,598
1875	1,100	13,632	14,732	1885	15,704	19,040	34,744
1876	3,979	11,715	15,694	1886	25,835	11,298	37,133

* Long tons, 2240 lbs.

OZOKERITE.

The chief source of ozokerite, or mineral wax, is Galicia, in Austria-Hungary, where the town of Boryslaw is the center of the industry. In the United States the mineral has been found near Thistle, Utah, and a small but increasing output is being made at that place.

Ozokerite varies from a very soft material to a substance as hard as gypsum. It has usually been regarded as a petroleum very rich in paraffine, but lately Dr. Wurtz has advanced the theory that it belongs with the olefines, and has originated by polymeric change from petroleum. The density of ozokerite ranges from 0.850 to 0.950, and its melting point from 58° C. to 100° C. It is soluble in oil of turpentine, benzol, and petroleum. Ordinary Galician ozokerite is soft and plastic, and has a very fibrous fracture. Its color varies from light yellow to dark brown, and it frequently has a greenish hue owing to dichroism.

Uses.—Ozokerite is largely used in Europe, especially in Russia, as a substitute for beeswax. Refined ozokerite, or ceresin, is distilled, and the resulting wax is employed for the manufacture of candles, which are especially adapted for use in high temperatures, as they are less likely to gutter and bend than ordinary paraffine candles. Another product made from ozokerite by distillation resembles vaseline, and is used in ointments and pomades. By the action of Nordhausen sulphuric acid it is rendered white, and is consumed in that form by French perfumers as a substitute for lard in the process of *enfleurage*, the almost entire insolubility of the hydrocarbon in alcohol giving it great advantage over the animal fat. The residue in the retorts after distillation consists of a hard, black, waxy substance which is used for the manufacture of okonite, a valuable electrical insulating material. The black ozokerite residue is combined with india-rubber, welded by passing through rollers at moderate temperature, and vulcanized. Okonite is not only a good insulator, but is remarkably flexible and tough.

UNITED STATES: PRODUCTION AND IMPORTS OF MINERAL WAX.

Year.	Production.		Imports.*	
	Pounds.	Value.	Pounds.	Value.
1883	....	....	565,658	$29,332
1884	....	....	617,992	69,026
1885	....	....	1,056,438	123,976
1886	....	....	800,496	71,220
1887	....	....	718,769	59,084
1888	43,500	$3,000	1,164,940	89,131
1889	50,000	2,500	1,078,725	86,682
1890	350,000	26,250	1,669,241	142,333
1891	50,000	3,000	1,869,241	149,539
1892	130,000	7,800	1,250,000	150,000

* For fiscal years ending June 30 prior to 1886; calendar years subsequently.

PRODUCTION OF OZOKERITE IN AUSTRIA-HUNGARY.

Year.	Centners of 100 Kilos.	Average Price per Centner. Fl.* K.	Year.	Centners of 100 Kilos.	Average Price per Centner. Fl.* K.
1877....	89,610	25 73	1884....	119,669	31 31
1878....	103.420	29 80	1885....	130,258	29 72
1879....	90,666	25 89	1886....	139,254	25 42
1880....	105,270	34 94	1887...	80,500	23 67
1881....	106,491	25 84	1888....	87,800	24 66
1882....	99,300	25 50	1889....	75,600	23 76
1883....	106,299	28 78	1890....	61,699	28 50

* The florin is equivalent to 48.2 cents.

A full account of the Galician ozokerite industry is given by Mr. Boverton Redwood, F.C.S., in the *Journal of the Society of Chemical Industry*, Feb. 29, 1892. pp. 93–119, from which much of the data in this article is taken.

BARYTES.

BARYTES is produced in the United States chiefly in Missouri, North Carolina, and Virginia. A small amount is mined in Illinois, and a few thousand tons are imported annually and prepared for market at works in New Haven, Conn. Lynchburg, Va., and St. Louis, Mo., are the principal markets for the domestic product. At the former place there is one manufacturer, and at the latter three. There is also a mill at Quincy, Ill., and there was one in North Carolina, which was burned the past year.

PRODUCTION OF CRUDE BARYTES IN THE UNITED STATES.

Year.	Short Tons.	Value.	Year.	Short Tons.	Value.	Year.	Short Tons.	Value.
1880........	22,400	$80,000	1885........	16,800	$75,000	1889........	21,469	$106,313
1881........	22,400	80,000	1886........	11,200	50,000	1890........	24,540	86,505
1882........	22,400	80,000	1887........	16,800	75,000	1891	34,796	118,363
1883........	30,240	108,000	1888.......	22,400	110,000	1892..... ..	29,680	106,000
1884	28,000	100,000						

The figures from 1880 to 1891, inclusive, are taken from the *Mineral Products of the United States*, published by the United States Geological Survey.

Barytes, or heavy spar, sulphate of barium, is a dense white mineral, easily scratched with a knife, and of the extraordinarily high specific gravity 4.5. It is a frequent gangue in mineral veins, and is often found in connection with galena and zinc blende. It also occurs as a vein-filling and as pockets in many limestone districts, and deposits of this nature are its chief commercial source. The mining is in general somewhat irregular, and is carried on, especially in Missouri, by farmers in off-times. The mineral is there known as "tiff."

Barytes of the best grade should be free from impurities, especially quartz and iron stains. The former injures the mills in grinding, as it is so much harder than the barytes, while the latter injures the color of the paint. In preparation the barytes is crushed to the size of buckshot and then boiled in sulphuric acid to remove the iron rust. It is then boiled in distilled water to remove the acid and iron salts, dried, and ground. It is next sorted by "floating in water," as it is called. The coarser portion settles quickly, while the very finest, which gives the best grade of pigment, remains longest in suspension. It is finally dried by steam, barreled, and shipped. The principal use is as a pigment. As barytes is worth from 1c. to 1½c. a pound, and the value of white lead is 6c. or 7c., it is a tempting adulterant for the latter. However, it can hardly be said to injure the pigment, the objection being that the purchaser pays for one thing and gets another. For

some purposes it has its own decided advantages as a paint in the fact that sulphurous gases do not discolor it. Crude barytes is worth about $5 per ton, spot value.

IMPORTS OF BARIUM SULPHATE.

Year.*	Manufactured.		Unmanufactured.		Year.*	Manufactured.		Unmanufactured.	
	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.	Pounds.	Value.
1867	14,968,181	$141,273	....	....	1880	4,924,423	$37,374	....	....
1868	2,755,547	26,739	....	....	1881	1,518,322	11,471	....	....
1869	1,117,335	8,565	....	....	1882	562,300	3,856	....	....
1870	1,684,916	12,917	....	....	1883	411,666	2,489	....	....
1871	1,385,004	9,769	....	....	1884	3,884,516	24,671	5,800,816	$8,044
1872	5,804,098	43,521	....	....	1885	4,095,287	20,606	7,841,715	13,567
1873	6,939,425	53,759	....	....	1886	3,476,691	18,338	6,588,872	8,862
1874	4,788,966	42,235	....	....	1887	4,057,831	19,769	10,190,848	13,205
1875	2,117,854	17,995	....	....	1888	3,821,842	17,135	6,504,975	9,037
1876	2,655,349	25,325	....	....	1889	3,601,506	22,458	13,571,206	7,660
1877	2,388,373	19,273	....	....	1890	3,125,670	16,453	9,629,172	13,133
1878	1,366,857	10,340	....	....	1891	4,813,760	22,041	11,043,200	4,505
1879	453,333	3,496	....	....	1892†	1,845,760	8,989	3,507,840	15,371

* Fiscal years ending June 30 until 1884; calendar years subsequently.
† Six months.

BAUXITE.

During the past year the new mineral industry of bauxite mining has begun to assume important proportions in Georgia and Alabama. Deposits of this mineral exist in Floyd County, Georgia, and in Cherokee, Calhoun, and Cleburne counties, Alabama, extending over an area about 75 by 30 miles. There are also important deposits in Arkansas, discovered in 1891, but these have not yet been opened.

The Southern Bauxite Company and the Republic Mining Company, which are the principal producers, have made shipments during 1892 as follows:

Company.	Georgia.	Alabama.	Total.
	Tons.	Tons.	Tons.
Southern Bauxite Co	2,000	3,000	5,000
Republic Mining Co	....	4,200	4,200
Total	2,000	7,200	9,200

The imports of bauxite into the United States are classed under the heading "terra alba, or bauxite," and are classified as "not aluminous" and "aluminous." The amount and value of the latter variety, which may be called "bauxite," imported into the United States is given in the following table:

IMPORTS OF BAUXITE INTO THE UNITED STATES.

Years.*	Pounds.	Value.	Years *	Pounds.	Value.	Years.*	Pounds.	Value.	Years.*	Pounds.	Value.
1873	......	$44,995	1878	....	$685	1883	10,592,552	$19,533	1888	20.899,516	$40,761
1874	......	86,820	1879	....	7,080	1884	10.066.496	25.188	1889	28,945,674	60,292
1875	......	45,725	1880	....	14,737	1885	20,510,540	41,378	1890	27.503,730	46,137
1876	......	20,875	1881	....	9,795	1886	15,988.807	33,223	1891	17,936,504	46.252
1877	......	345	1882	12,008,101	30,525	1887	10,824,749	29,809	1892	12,804,253	57,948

* Fiscal years ending June 30 until 1886; calendar years subsequently.

From a description of the developments in the Georgia-Alabama bauxite region, by Mr. Henry McCalley, before the Alabama Industrial and Scientific Society, Birmingham, Ala., Nov. 16, 1892, we make the following abstracts:

The discovery of bauxite, hydrous oxide of aluminum, was made in 1821, at Baux, France, but the mineral did not come into use commercially until 1868. It occurs also in Ireland, Austria, and Asia Minor, and in the United States in Georgia, Alabama, Arkansas, and North Carolina. The first discovery of bauxite in this

country seems to have been in 1887, in Pike County, Georgia; then in 1889, in Cherokee County, Alabama; and in 1891, in Pulaski County, Arkansas. In Alabama it was discovered by J. R. Trotter, superintendent of the iron-ore banks of the Bass Furnace Company, Cherokee County.* It was afterward discovered at the Walker iron-ore banks, near Jacksonville, Calhoun County, and at the Laney manganese banks, in Cleburne County. Two other deposits have been found near Anniston, in Calhoun County. All the Alabama deposits occur in the lower part of the Lower Silurian formation. The district in which the Alabama bauxite occurs has been badly broken up by sharp folds and great thrust faults. The mineral occurs as pockets in close association with brown iron ore (limonite) and clay. In Cherokee County the deposits appear to be along two parallel lines of outcrop, that run in a general northeast and southwest direction, and are from 150 to 200 yards apart, following the crest of two sharp anticlinal folds.

In places the bauxite overlies a white or yellow sandstone, for the most part friable, but sometimes hard and cherty, and underlies an unctuous clay in the upper part of which the brown ore occurs. At one end the bauxite shows as an irregular seam of about 60 ft. in thickness. An excavation about 75 ft. deep has been made. To the southeast of Dike's bank, some 200 yards, is the bauxite deposit owned by the Republic Mining Company. Here the mineral occurs in two irregular seams, separated in places by a band of unctuous clay of 15 ft. thickness, but cutting out to a mere selvage. The upper seam is about 30 ft. thick, the lower 20 ft. To the northeast of Dike's bank is the deposit owned by the Southern Bauxite Company. The deposit had been tested to a depth of 20 ft., and was still good. Half a mile farther toward the northeast is the Warwhoop deposit of the same company, tested for 20 ft. and still good. There is no reasonable doubt of the extent of the bauxite deposits in this district; they have been tested over two miles, and have not been found less than 15 ft. in thickness, and at places from 20 to 30 ft. The average composition of the Cherokee County bauxite, as per car-load sample, is as follows: Alumina, 56% to 60%; oxide of iron, 2.75%; insoluble silicate matter, 7%; titanic acid, 2% to 3%; water, 25% to 30%.

The ore is hauled in wagons three miles to Rock Run, and then three miles more over the private railway of the Bass Furnace Company to Rock Run station, on the East Tennessee, Virginia and Georgia Railway. It is shipped to Philadelphia and Natrona, Pa., and to Syracuse, Buffalo, and Brooklyn, N. Y. It is used principally in the manufacture of alum, for which purpose the insoluble matter should not exceed 7% nor the oxide of iron 2.75%. Alabama bauxite is slowly but surely making its way against foreign ore, and on account of its easy solubility is preferred to the ore which carries alumina in part as insoluble silicate.

* The discovery of Bauxite in Alabama is also claimed by R. Swain Perry, E.M., Piedmont, Alabama.

BORAX.

By Prof. J. F. Kemp.

The borax of commerce is obtained from three or four important minerals, although there are a great many others that contain boracic acid. The source most economically worked is the native mineral called borax or tinkal, having a composition $2(NaBO_2.HBO_2) + 9H_2O$, or $Na_2O.2B_2O_3 + 10H_2O$, with B_2O_3 36.65%. This forms monoclinic crystals of prismatic habit, and is sometimes called prismatic borax. The mineral sassolite or boric acid, H_3BO_3, occurs chiefly in solution. Ulexite or boronatrocalcite is a calcium-sodium borate, $NaCaB_2O_9 + 5H_2O$, with B_2O_3, 49.7%. It is called cotton-ball borax in California when in tufts of acicular crystals, and requires treatment in order to yield the borax of commerce. Priceite, also important in the West, is a calcium borate with little or no soda. Pandermite, from Asia Minor, has the composition $Ca_2B_6O_{11} + 4H_2O$, and stassfurtite, from the Stassfurt salt mines, $2Mg_3B_8O_{15} + MgCl_2$.

Occurrence.—The boracic minerals in workable quantities were formerly obtained entirely from the alkaline deposits left on the bottoms of dried lakes, or from hot springs (as in Tuscany), which bring them directly to the surface. Within the last few years, however, in California deep mining has gone far ahead of the marshes; so much so that in 1892 the former furnished 4500 tons and the latter but 1000. In the same time 1500 tons were gathered from the Nevada marshes.

California and Nevada.—As is very generally known, the portion of the United States lying between the Wasatch Mountains and the Sierra Nevada is called the Great Basin. Although it stands at a general altitude on the north of 4000 ft. above tide, it is relatively depressed, and none of its streams reach the ocean. It forms an alkaline plain, broken by various subordinate ranges, and marked by numerous "salines," which are, as in the case of the Great Salt Lake, the shrunken remains of former large fresh-water lakes. The Great Basin (so called by General Frémont) extends from southeastern Oregon and southern Idaho across Utah, Nevada, and northwestern Arizona, and around into southeastern California. It is marked by slight rainfall, absence of water, and, in the south, by great heat. At least ten salines, or "marshes," along the Nevada-California border and in

California have been found to contain boracic deposits. The marshes are the old beds of relatively restricted lakes, which received boracic water, probably from hot springs. Volcanic phenomena are abundant in the region, and were doubtless the principal stimulating cause. The borate of lime and soda (ulexite), the borate of lime (priceite), and the borate of soda (borax) are all found, and always mingled with dust, and more or less gypsum, sodium carbonate, sodium chloride, sodium sulphate, and various other alkaline salts. Artesian wells have shown standing water at no great depth in some of the marshes, and in at least one instance it is charged with borax. The crust of borax is often renewed on the surface after it has been removed, and after an interval of three or four years may be gathered again. This is due to capillary attraction through the pores of the underlying soil.

The best known of the salines in Nevada are Teel's Marsh, Columbus Marsh, Fish Lake Valley, and Rhodes Marsh, all in Esmeralda County. Although the marshes cover thousands of acres, the portions productive of borax are comparatively limited. Previous to 1890 the Pacific Coast Borax Company and the Preservaline Company operated the Columbus Marsh, the Nevada Borax Company the Rhodes Marsh, and Smith Brothers Teel's Marsh, but in that year nearly all the companies of Nevada and California combined under the name of the Pacific Coast Borax Company.

There is a minor deposit at Salt Wells, in Churchill County, Nev., and in California there are three marshes in Inyo County—the Saline Valley (said to be the largest of all), the Amargosa, and the Furnace Creek; one in San Bernardino County, the Slate Range or Searles Marsh; and one, of less present importance, at Little Borax Lake, Lake County. The last-named is north of San Francisco. Borax is also shown by analysis to be present in the water of Owens Lake, and boracic acid is found in the water of Mono Lake to the extent of 0.16 gram per liter.

Special mention should be made of the vein of calcium borate in the Calico district of San Bernardino County. It is a fissure vein, and is obtained precisely as any other vein deposit. The great importance attained by the deep mining of borax was referred to above.

Of more recent discovery are the deposits of priceite in large masses in the ground at Chetco, Curry County, Ore. As they are near the coast, transportation to San Francisco is cheap and the product is considerable, although occurring irregularly and with no surface indications. Borates are also reported from Washington.

To show the general composition of the alkaline crusts in the salines the following table of analyses by Mr. C. W. Hake is given. The materials came from the Searles Marsh at successive stages of its growth, as indicated.

	Six Months' Growth.	Two Years' Growth.	Three Years' Growth.	Four Years' Growth.
Sand	58.0%	55.4%	52.4%	53.3%
Sodium carbonate	5.2	5.0	8.1	8.0
Sodium sulphate	11.7	6.7	16.6	16.0
Sodium chloride	10.9	20.0	11.1	11.8
Borax	14.2	12.9	11.8	10.9
Totals	100.0	100.0	100.0	100.0

Foreign Sources.—The foreign sources of borax are the following : the Tuscan hot springs; the ulexite bed at Suzurlu, in Asia Minor; the alkaline beds in Southern Thibet; the similar deposits in Northern Chile, in the region ceded by Bolivia after the late war; and the salt mines of Stassfurt, in Germany.

Asia Minor.—Of the deposits at Suzurlu, in Asia Minor, scanty geological information is available. They export about 8000 tons of calcium borate, pandermite, annually. They were opened in 1869, and afford the mineral in thick, white, and fairly hard lumps.

Chile.—The Chilean salines are of variable output. The mineral is ulexite, and is reported from two principal points—Maricunga, north of Copiapo, and Ascutan, near the Bolivian line. Maricunga is over 12,000 ft. above sea-level. Both of these contain the borate on dried-lake bottoms, in association with various alkaline salts, and practically as described for California. The difficulties of treating ulexite led to failure in the early attempts at development, especially at Maricunga, but Ascutan is now an important source for the German and English markets. The Argentine Republic also ships borax to Germany.

Germany.—Considerable quantities of stassfurtite are annually afforded by the salt mines at Stassfurt. The mineral occurs as small masses, from the size of a barley-corn to that of a bean, embedded in the salt.

Italy.—The Tuscan hot springs are situated west of Sienna, in the valleys of several small rivers. They come up through Cretaceous, Eocene, and Miocene strata, and are a phase of expiring volcanic activity. They were found to contain boracic acid in 1777, but were not utilized until long afterward. The waters are led into tanks and are evaporated by the heat from neighboring springs. The product is sassolite or crystallized boracic acid, from which borax is made with soda. For a very long time these springs were the chief source of borax, but many years ago the demand far outran their capacity. Reference should be made to the small amounts of sassolite that were obtained from 1873 to 1877 in the crater Vulcano, on the Lipari Islands. It was deposited in cracks by ascending vapors, but a later eruption from the old vent destroyed the supply and the industry.

Thibet.—The sources of supply in Thibet and Northern India are of old development. The mineral from this locality first received the name tinkal. It reaches the shipping points in India after being carried across the Himalayas by sheep as the principal beasts of burden. This borax was the earliest used, and came into prominence in the metallurgy of the precious metals. Its substitute is obtained from alkaline deserts.

Methods of Treatment.—In California and Nevada the sand, or clay, etc., which contains the native borax is dug up, allowed to dry, and then taken to tanks, in which it is boiled in water and lixiviated. The heat is usually imparted to the solutions by means of steam-coils, and the fuel is such as can be obtained in the neighborhood. The water is derived from artesian wells. After having been thoroughly leached the solution is settled and piped off into crystallizing vats, in which it cools and deposits the borax. These vats are commonly made of galvanized iron. If the crystals are dirty and impure, resolution and recrystallization may be necessary. Care is also taken to get all the borax of the original residues, and not to let the solutions escape after crystallization until all the borax is out of

them. The climate is excessively hot, and in some regions difficulty is experienced in the summer months in gaining a temperature low enough to cause the crystals to form. In some marshes the borax occurs as well-formed crystals embedded in the clay and soil, but in general it is in a too finely divided condition to be so apparent.

There is no great difficulty in treating native borax, but with ulexite it is a different matter. This can be changed to the borate of soda, in part, by boiling with sodium carbonate, but losses ensue in that the reaction is not complete, so that various other processes have been devised. Steam alone has the power, when superheated and passed over ulexite, of volatilizing the boracic acid and yielding sassolite. In the Formhals process the fumes of burning sulphur are introduced into a hot emulsion of ulexite in water. Sodium sulphite and sassolite are yielded. In the Robertson process there are conducted into a similar emulsion the fumes which are employed in the usual manufacture of sulphuric acid. In the Gutzkow process the ulexite is first treated with sulphuric acid, and then the gypseous residue is distilled with superheated steam. But by whatever process the solution of borax is derived, some precautions in obtaining its crystals are necessary. Thus, borax ($Na_2O_2,2B_2O_3 + 10H_2O$) crystallizes best when an excess of sodium carbonate is added to the solution, equal in amount to five per cent of the resulting borax. But if the excess be too great, the neutral borax ($NaBO_2 + 4H_2O$) results. Further, if the hot solution exceeds 24°–28° B. in specific gravity, octahedral borax ($Na_2B_4O_7 + 5H_2O$) is formed. For large crystals, slow cooling in capacious vats is necessary. For small crystals, small vats, which are kept in agitation, are best.

The earlier American works used only the crude borax, but now the Pacific Coast Borax Company has a large plant at Alameda, Cal., wherein the calcium borate is treated. The crystals form on steel rods.

PRODUCTION OF BORAX IN THE UNITED STATES.

Year.	Chief Fields producing.	California, Pounds.	Nevada, Pounds.	Total Product.	Av. Wholesale Price in N. Y. in Cents.
1864..	Borax Lake, Lake Co., Cal.	24,304	....	24,304	39
1865..	“ “ “	251,092	....	251,092	37½
1866..	“ “ “	401,632	....	401,632	33
1867..	“ “ “	439,824	....	439,824	35½
1868..	“ “ “	64,513	....	64,513	33⅓
1869..	....	....	....	....	35½
1870..	....	....	....	....	30½
1871..	....	....	....	....	31¼
1872..	Hackinhama, Lake Co., Cal.	280,000	....	280,000	32
1873..	San Bernardino, Cal., and the Nevada marshes...	1,030,000	970,000	2,000,000	24⅘
1874..	“ “ “ “ “	1,829,771	2,170,138	3,999,909	14⅛
1875..	“ “ “ “ “	2,336,000	2,804,000	5,140,000	12⅝
1876..	“ “ “ “ “	2,873,909	2,307,001	5,180,910	10⅞
1877..	“ “ “ “ “	1,986,970	2,740,310	4,727,280	9¾
1878..	“ “ “ “ “	746,840	2,055,960	2,802,800	8⅞
1879..	“ “ “ “ “	727,146	827,840	1,554,986	9
1880..	“ “ “ “ “	1,219,948	2,640,800	3,860,748	12¼
1881..	“ “ “ “ “	1,380,205	2,665,200	4,045,405	13¼
1882..	Same and Death Valley and Amargosa, Cal.	1,465,732	2,770,559	4,236,291	13¾
1883..	Same and Calico Mine, Cal.	1,800,000	3,800,000	5,600,000	14¼
1884..	“ “ “	2,037,940	5,675,363	7,713,303	9¼
1885..	“ “ “	1,885,300	5,586,104	7,471,404	8¼
1886..	“ “ “	2,569,630	6,524,542	9,094,172	6¾
1887..	(Suspension at Death Valley and Amargosa)	2,029,380	5,571,735	7,601,115	5¾
1888..	Calico, San Bernardino, and Nevada marshes	2,809,088	4,004,355	6,813,443	7
1889..	Same and Saline Valley, Cal.	1,939,650	5,333,482	7,273,132	7⅓
1890..	“ “ “	6,402,034	5,487,794	11,889,828	7½
1891..	“ “ “	8,533,337	3,296,663	11,830,000	7¼
1892..	“ “ “	11,596,574	2,646,525	14,243,099	7½
	Totals	58,660,819	69,878,371	128,539,190	

Commercial borax is a white crystalline substance or powder, of a sweetish taste, and of manifold uses. One of the chief employments is in welding and other metallurgical operations, its office being to afford a convenient flux. It forms fusible salts with almost all metallic oxides. It is the basis of the enamel so much applied to iron utensils, glazed brick, and much china. earthenware, and tiling. It dissolves the glutinous matter from raw silk, and aids the dyer as a mordant. It is employed in the laundry with starch to give glossy linen. The meat-packers use over 1000 tons yearly as an antiseptic, while in soap it is very serviceable in hard waters. A large number of drugs contain it, and its uses are many and annually increasing.

Literature.—The general distribution of borax, etc., is described in the *Third Annual Report of the California State Mineralogist*, 1883. On the Western localities, see other reports of the California State Mineralogists, and the *Mineral Resources of the United States*, especially for 1882; also, the *Oil, Paint, and Drug Reporter*, March, 1891, pp. 10, 25, and the *Chemical News*, Feb. 13, 1891, giving many analyses of crude material. On the history of the Western discoveries, see the *Engineering and Mining Journal*, Sept. 10, 1892. On the Chilean deposits see Darapsky, *Chemiker Zeitung*, 1887, No. 40, p. 605 and elsewhere; also, 1885, p. 1305, and 1886, No. 10. On the Italian (Tuscan) springs, see *American Journal of Science*, II., xix. 119, and *Revue Universelle des Mines*, September and October 1883, p. 417; also, *Third Annual Report California State Mineralogist.*

BROMINE.

Bromine is an element closely allied to chlorine. It is not found in the free state in nature, but always in combination with some other element, as a bromide. At the ordinary temperature bromine is a liquid of dark brown-red color, about three times as heavy as water, and highly poisonous. It boils at about 60° C., but is very volatile even at the ordinary temperature of the air.

Occurrence.—Bromides occur in small quantities in sea-water, and in the water of many saline springs. The brines produced in the salt regions of West Virginia and Pennsylvania, in Midland County, Michigan, and in the Tuscarawas Valley and Pomeroy, Ohio, contain so large a proportion of bromides that it is profitable to save them and prepare bromine as a by-product. All the bromine produced in the United States comes from these sources.

Manufacture.—The bromides in the brine from the West Virginia and Ohio salt wells are concentrated in the bittern during the process of salt manufacture. The bittern, at a specific gravity ranging from 35° B. to 42° B., is treated with sulphuric acid and black oxide of manganese (pyrolusite), the amount of reagents used being dependent upon the percentage of bromides in the bittern. The sulphuric acid combines with the base of the bromide and forms hydrobromic acid; the latter is oxidized by the pyrolusite with the evolution of bromine gas, which is collected and condensed in suitable vessels. In Michigan potassium chlorate is the favorite oxidizing agent because of the large proportion of calcium chloride in the liquor.

Production.—The production of bromine in the United States since 1880, with the value of the output at the works, is given in the following table:

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1880	404,690	$114,752	1885	320,000	$92,800	1889	418,891	$125,667
1881	300,000	75,000	1886	428,334	141,350	1890	387,847	104,719
1882	250,000	75,000	1887	199,087	61,717	1891	368,786	73,757
1883	301,100	72,264	1888	307,386	95,290	1892	379,480	64,512
1884	281,100	67,464						

Uses.—The manufacturing chemists are the principal consumers of bromine, using it in the preparation of bromides, chiefly potassium bromide. A small part of the product is used in the manufacture of eosene, an aniline color, and smaller amounts as a disinfectant. The use of bromine as a substitute for chlorine in the metallurgical treatment of gold ores has been proposed, but it has not, so far, been employed for this purpose to an important extent.

Price.—Until March, 1891, there existed an agreement between the National Bromine Company, which comprised most of the manufacturers of this country, and the German producers, to limit their sales to the United States and Europe, respectively; the National Bromine Company also had an understanding with some of the largest consumers of this country concerning the sale of the product controlled by it. Up to this time the price of bromine had been nominally 32c. per lb., delivered. In March the contracts between the consumers and the National Bromine Company expired, and the latter, being unable to renew them, dissolved ; the compact with the German producers was of course terminated thereby. The stocks which had accumulated in the United States were then offered for shipment abroad, and parcels were sold in England, France, and Germany at reduced prices. This move on the part of the Americans brought about a retaliation from the German makers, who sent bromine as well as bromides to this country, and made sales at prices lower than any before quoted in this market. The lowest point reached was 17½c. per lb., and the average price realized by the American manufacturers during the year 1891 was not over 20c. Throughout 1892 bromine continued to rule low, and the average selling price at the works was about 17c.

CEMENT.

By William Allen Smith, E.M.

The hydraulic cements used in construction are known as Natural Hydraulic and Portland. Intermediate grades, called Roman, Semi-Portland, etc., are made by mixing these two. In the East the name of Rosendale is now generally given to all common hydraulic cements made directly from natural rock. These were first made in 1832 at Rosendale, Ulster County, N. Y., and the Rosendale district has since then been the largest producer of common cement. Other brands of natural hydraulic cement are known as Akron, Louisville, Milwaukee, etc., from the locality of their manufacture.

Portland cement is so called from the resemblance of mortar made from it to the English Portland stone. It was first made in England in 1824, and in this country at Coplay, Pa., in 1878.

The property of "hydraulicity," or hardening in contact with water, was discovered in 1818 by Vicat, a French engineer. This property, which has been much discussed, is doubtless due to the crystallizing energy developed by combination of water with the silicates of lime and alumina formed by calcining argillo-magnesian limestones or mixtures of clay and carbonate of lime.

Natural Hydraulic Cement.—Natural hydraulic cements are made from argillo-magnesian limestones, which are found in great abundance, mostly in rocks of Upper Silurian age. The industry of cement-making has sprung up around certain centers in many parts of the land.

The following table shows analyses of natural rock used in various parts of the country in the manufacture of cement:

ANALYSES OF CEMENT ROCK.

	Ulster Co., Rosendale.	Ulster Co., Rosendale. "Light."	Utica, Ill.	Milwaukee, Wis.	Fort Scott, Kan.	Cement, Georgia.	Siegfried, Pa.	Coplay, Pa.
Carbonate of lime	45.91	50.82	42.25	45.54	65.21	43.50	78.92	67.14
Carbonate of magnesia	26.14	17.74	31.98	32.46	10.65	22.00	2 66	2.90
Silica and insoluble	15.37	22.66	21.12	17.56	15.21	22.10	11.62	18.34
Sesquioxide of iron	11.38	2.39	1.12	3.03	....	1.80	6.25	7.49
Alumina				1.41	4.56	5.45		
Sulphate of lime	....	4.37	....	....	....	....	....	....
Oxide of manganese	....	0.55	....	....	....	....	....	....
Potash and soda	....	traces	....	....	....	0.22	....	0.19
Organic matter	....	0.99	....	....	....	....	....	
Water	1.20	....	1.07	....	....	4.95	....	3.94
Undetermined		.48	2.46	....	4.37	....	0.55	
Totals	100.00	100.00	100.00	100.00	100.00	100.02	100.00	100.00

These will serve as typical analyses of rock from which natural hydraulic cement has been successfully made for many years. It will be noticed that, with two exceptions, the percentage of magnesia is considerable. The Lehigh Valley cement rock, of which examples are given from Siegfried and Coplay, Pa., contains only a small percentage of magnesia. This rock is often called a natural Portland rock, and many of the Lehigh Valley cement factories now make Portland cement from it.

The process of manufacture consists in quarrying and breaking the rock, calcining in kilns, which are usually continuous in operation, and grinding. The burning is light, and usually not strong enough to expel all the carbonic acid in the rock. The cement until ground is simply a mass of partially vitrified clinker, which is not affected by water. It is only after it is ground that the addition of water induces crystallization of the silicates formed by calcination. The degree of fineness is wholly a matter of economy. Coarse particles will have no "setting" power, and may for practical purposes be considered as so much sand. The usual demand of fineness is that 90% to 95% shall pass through a sieve of 2500 meshes to the square inch.

Following are typical analyses of natural hydraulic cement:

ANALYSES OF NATURAL HYDRAULIC CEMENT.

	Rosendale, Ulster Co., N. Y.	Utica, Ill.	Akron, N. Y.	Lehigh Valley, Pa.	Lehigh Valley, Pa.	Louisville, Ky.
Silica	22.75	35.43	29.64	18.18	18.28	21.10
Alumina and Fe_2O_3	16.70	9.92	6.42	9.78	7.43	7.51
Lime	37.60	33.67	54.77	69.18	51.53	44.40
Magnesia	16.65	20.98	9.17	1.98	2.07	7.00
Alkalis	....	....	....	....	1.50	0.80
Carbonic acid	5.00	....	....	....	16.26	11.18
Sulphate of lime		....	....	....	....	6.85
Water	1.30	....	....	....	....	1.16
Undetermined		....	....	.88	2.93	....
Total	100.00	100.00	100.00	100.00	100.00	100.00

The cement is packed in barrels or sacks, or is sold in bulk when to be used immediately. Engineers' specifications demand that cement shall be freshly ground, as it is apt to absorb moisture. In the Eastern works barrels contain 300 lbs. net, and in the West 265 lbs. net.

Natural as compared with Portland cement is light, quick-setting, and has less ultimate strength. On account of its quick-setting quality it is preferred for work to be laid under water. It weighs from 49 to 56 lbs. per cubic foot, and sets in from 2 to 30 minutes. If of good quality, it shows a gradual increase in tensile strength up to one year, and even longer.

Color is not now regarded as of much importance. Formerly the darker-colored cements were preferred, but many of the light-colored cements now made give fully as good results. The color is chiefly due to oxides of iron and manganese, and it is only in comparing two lots of cement made from the same rock that color is regarded, a yellowish tinge indicating an under-burning.

Portland Cement is made either from natural rock or from mixtures of clay and carbonate of lime (chalk, marl, or compact limestone). The English and German Portlands are made from mixtures, as are the Portland cements of Onondaga County, New York, where a large deposit of marl is utilized. The most

important center of Portland-cement manufacture in this country is in the Lehigh Valley, where the cement is made from a natural rock, sometimes with addition of limestone. The industry has grown steadily from its first establishment there in 1878, until now American brands of Portland cement are recognized as nearly if not quite equal to the imported brands.

The natural rock contains about 22% of clay and 70% of carbonate of lime. After quarrying and breaking, it is ground, mixed with water to a paste, and made into bricks or balls. The bricks or balls are dried by waste heat from the top of the kilns and then thoroughly calcined, the kilns being intermittent in operation. The more intense the burning, within the limit of vitrification, so much the heavier and stronger will be the cement. The cement clinker is then ground to the proper fineness and packed in barrels of 400 lbs. net.

Artificial Portland cement, made from pure clay and carbonate of lime, is usually mixed wet, made into bricks or balls, burned, and ground. This is the process employed in England. Some of the German works prefer a dry mixing.

The usual method of burning is in a shaft-kiln, carefully charged in layers of cement bricks (or balls) and coke or coal. The burning takes three or four days. A full week is usually required to "turn a kiln." The product yields 95% of Portland clinker, the remainder being common cement.

Within recent years attempts have been made to burn Portland cement continuously in rotary kilns at the Atlas Works, near Coplay, Pa., and at Duryee's Works at Montezuma, N. Y.

Duryee's revolving furnace consists of a sheet-iron cylinder, 75 ft. long, inclined toward the firing end ⅜ in. to 1 ft. The lower hot end is 6 ft. in diameter for a length of 20 ft., and is lined 9 in. thick with a mixture of ground fire-brick and molasses. The remainder of the cylinder, 55 ft. long, has a diameter of 5 ft., and is lined with 6-in. fire-brick. Only the lining at the hot end requires renewal, and this can be replaced in 10 hours, at a cost of $25. The cylinder revolves on cast-iron rollers three times a minute. The power required is five horse-power.

At the lower end a small coal fire is kept up on a grate, but the chief fuel is crude petroleum, introduced in a jet which meets the hot-air blast. The consumption of oil is eight gallons per barrel of cement clinker produced. Fifteen barrels of oil are required to heat the furnace ready for burning cement.

The clay and marl are mixed wet and run in as a slurry at the upper end. The mixture in drying forms a sand, which moves slowly downward with the turning of the cylinder, and is finally discharged at the lower end as cement clinker of the size of small gravel. It takes two hours to run the particles through. The operation is continuous, and the product is 250 barrels per day. It is claimed that all the mixture is burned to Portland clinker.

The manufacture of Portland cement must be conducted throughout with greatest care. A chemist at the works is indispensable, as it is necessary to check from day to day the character of the material charged. It is generally held that 1½% to 2% of magnesia in Portland cement is dangerous, particularly if the cement is to be applied in a damp place. Free lime is also deleterious, and where this exists the cement is allowed to stand exposed to the air for several days, and the lime is air-slaked.

By the rules of the École Nationale of Paris, a Portland cement containing over 1½% of sulphuric acid, or 1½% of carbonic acid, or 1% of magnesia, should be rejected on analysis. On the other hand, cements showing a good analysis must be tested mechanically.

English and German Portland cements weigh from 77 to 90 lbs. per cubic ft.; some American brands as much as 95 lbs.

Portland cements are "slow-setting." They set usually inside of three hours, and then harden gradually for months and even years.

The quantity of water used in mixing has an important influence on the setting. A stiff paste, containing about 25% of water, gives best results for neat Portland cement; less water is used when the cement mortar contains sand, etc. The setting depends to a large extent on the formation of hydrosilicates, which are formed gradually. The chemically combined water in a pure cement mortar has been shown to be, after mixing, 0.99%; in 4 hours, 1.41%, increasing gradually up to 56 days, when it contains 11.60%. (Schiffner, quoted in an article on the manufacture of Portland cement, in the *Lehigh Quarterly* for October, 1892.)

The following tables show analyses of material used for making Portland cement at various points in this country, and analyses of different brands of American Portland with typical analyses of English and German Portland for comparison:

ANALYSES OF PORTLAND CEMENT MIXTURES.

	Coplay, Pa., Natural Rock (argillaceous limestone) and Limestone.		Warner's, N. Y., Clay and Marl.		Montezuma, N. Y., Clay and Marl.		Harper, Ohio, Clay and Marl.		Santa Cruz, Cal., Clay and Coral Rock.		Yankton, So. Dak., Clay and Limestone.		Phillipsburg, N. J., Natural Rock only.
	Argillaceous Limestone.	Limestone.	Clay.	Marl.	Clay.	Marl.	Clay.	Calcareous Marl.	Clay.	Coralline.	Clay.	Limestone.	Argillaceous Limestone.
Lime	37.60	50.15	11.25	51.55	6.62	47.68	17.80	50.95	2.83	51.31	5.28	51.00	42.00
Silica	18.34	4.46	44.74	1.06	50.08	6.22	47.45	1.98	63.73	2.40	61.53	4.14	16.00
Alumina	4.08	1.00	18.70	.64	14.50	1.70	19.85	0.97	22 12	.56	20.74	1.81	6.00
Sesquioxide of iron	3.41	.48	4.25	.35	4.61	.86			9.01	.51	4.01	2.72	2.00
Magnesia	1.39	.87	1.29	.91	4.40	.04	0.09	0.55	...	1.25	1.72	trace	0.38
Alkalies	.19	trace	1.20	....	5.10	2.20	4.34	0.12	.21	1.45	2.29	"	....
Carbonic acid	31.05	40.40	7.50	40.70	....	42.11	0.57	40.03	....	40.32	3.09	39.99	33.42
Sulphuric acid	......	....	2.78	2.07	....	....	....	....	....	....	....	....	....
Sulphur	.73	.15	....	....	....	....	1.03	0.10	....	....	1.26	0.50	....
Water	......	....	9.25	....	....	....	8.66	5.05	1.12	1.21	....	....	....
Organic and undetermined	3.21	2.49	...	2.86	14.69	....	0.21	0.25	.98	0.99	.08	....	0.20
Totals	100.00	100.00	100.96	100.14	100.00	100.81	100.00	100.00	100.00	100.00	100.00	100.16	100.00

ANALYSES OF PORTLAND CEMENT.

	Buckeye, Harper, Ohio.	Phillipsburg, N. J.	Coplay, Pa.	Onondaga Co., N. Y.	Onondaga Co., N. Y.	Santa Cruz, Cal.	Yankton, S. D.	Egypt, Pa.	Buffalo, N. Y.	High-grade, English.	Alsen & Son, German.
Silica	20.75	22	20.64	22.19	22.10	23.48	22.00	22.90	32.22	25.00	24.90
Alumina	13.50	9	6.93	6.35	6 84	8.47	7.74	12.10	10.91	12.00	11.22
Sesquioxide of iron		4	5.41	3.85	2.10	5.18	4.61		.12		
Lime	62.25	62	62.79	63.35	63.00	61.91	59.50	60.13	56.75	60.00	59.98
Magnesia	0.25	1	1.72	3.25	.97	....	0.90	4.20		1.00	0.38
Sulphuric acid	0.25	....	.11	1.20	...	....	0.80		....	....	0.86
Alkalies	2.25	....	.27	....	4.00	.92	1.20		....	1.00	0.50
Manganese oxide	0.20	....	....	....	....	....	....	....	....	....	....
Water	0.26	....	...	....	....	...	0.60	....	....	....	....
Carbonic acid	0.21	0.5	.99	....	.90	...	0.50	....	....	....	....
Losses and undetermined	.08	1.5	1.14	....	.09	.04	2.15	.67	....	1.00	2.16
Totals	100.00	100.0	100.00	100.19	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TESTING CEMENTS.

The tests of hydraulic cements recommended by the committee of the American Society of Civil Engineers, June 21, 1885, relate to fineness, checking or cracking, and tensile strength. We quote from these recommendations:

Fineness.—Fineness is no sure indication of the value of a cement, although all cements are improved by fine grinding. Cement of the better grades is now usually ground so fine that only from 5% to 10% is rejected by a sieve of 2500 meshes per square inch, and it has been made so fine that only from 3% to 10% is rejected by a sieve of 32,000 meshes per square inch. The finer the cement, if otherwise good, the larger dose of sand it will take, and the greater its value.

Checking or Cracking.—This is a simple but important test. A cake of neat cement, two or three inches in diameter, about half an inch thick, with thin edges, mixed with water to plastic stiffness, is allowed to harden in air, and then placed in water and examined from day to day, to see whether it becomes contorted or cracked on the edges. In some cases the tendency to crack, if caused by the presence of too much unslaked lime, will disappear with age.

A color test is sometimes made with a similar cake, kept in air. A good cement will retain its uniform color; yellowish blotches indicate uneven burning.

Tensile Strength.—The cement is made into briquettes, both neat and mixed with sand, the proportions of cement, sand, and water being carefully weighed. The proportions of water used in making briquettes are approximately as follows: Neat Portland, 25%; neat Rosendale, 30%; 1 part cement and 1 part sand, 15% of weight of cement and sand; 1 part cement and 3 parts sand, 12% of weight of cement and sand.

The briquettes are molded while plastic, taken from the molds as soon as hard enough, and covered with a damp cloth until used. Fresh, clean water at a temperature of from 60° to 70° F. should be used for mixture and immersion. An average of five briquettes may be made for each test, and briquettes should be broken immediately after taking out of the water, the temperature of which and of the room should be kept constant between 60° and 70° F.

TENSILE STRENGTH OF GOOD CEMENT MORTARS.

Age of Mortar when Tested.		Average Tensile Strength in Pounds per Square Inch.			
		Portland.		Rosendale.	
		Min.	Max.	Min.	Max.
	Clear Cement.				
1 day.	1 hour, or until set, in air; remainder of the time in water	100	140	40	80
1 week.	1 day in air; remainder of the time in water	250	550	60	100
4 weeks.	1 " " " " " " " "	350	700	100	150
1 year.	1 " " " " " " " "	450	800	300	400
	1 part Cement to 1 part Sand.				
1 week.	1 day in air; remainder of the time in water	....	....	30	50
4 weeks.	1 " " " " " " " "	....	....	50	80
1 year.	1 " " " " " " " "	....	....	200	300
	1 part Cement to 3 parts Sand.				
1 week.	1 day in air; remainder of the time in water	80	125	....	....
4 weeks.	1 " " " " " " " "	100	200	....	....
1 year.	1 " " " " " " " "	200	350	....	....

CONSUMPTION OF HYDRAULIC CEMENTS.

The use of hydraulic cements has grown enormously in recent years. The total of production and imports in 1880 was under 2,500,000 barrels; in 1891, over 11,000,000 barrels; and in 1892, 11,000,000 barrels.

The increased consumption is due not only to the natural growth of the country, but also to the demand for solidity of construction in all works of magnitude. Hydraulic cements are almost exclusively used now in railroad construction, fortifications, etc., and the consumption for concrete foundations, drain-pipes, etc., is continually increasing.

The erection of enormous office buildings in the large cities has consumed large quantities of cement, especially in the so-called "Chicago buildings," the pier foundations of which are made of pyramidal layers of iron or steel beams set and filled in with cement mortars.

The use of cement for floors and pavements has also increased enormously in the last few years. In New York alone over 2,000,000 sq. ft. of cement sidewalk were laid in 1892, and in Chicago over 7,600,000 sq. ft.

The annexed tables of production and imports will show the recent great increase in the consumption. The only cements imported are Portland brands, chiefly from Germany and England. The duty under the McKinley tariff is 8c. per 100 lbs., equal to 32c. per barrel. The fact that American production of Portland cement shows a decided tendency to increase, in the face of the enormous imports at low prices and under a moderate tariff, is greatly to the credit of the enterprise and skill of the makers.

PRODUCTION OF NATURAL HYDRAULIC CEMENT, 1891 AND 1892.

	1891.§			1892.‖		
	Mills.	Barrels.	Dollars.	Mills.	Barrels.	Dollars.
Rosendale District, Ulster County, N. Y.	17	2,815,010	2,252,008	*16	2,843,117	2,416,650
Onondaga County, N. Y. ("water lime")	8	288,941	188,944	8	280,000	182,000
Schoharie County, New York	1	27,055	21,644	1	15,000	11,250
Akron and Buffalo, N. Y.	4	788,300	575,283	4	825,000	498,750
Lehigh Valley, Pennsylvania	6	695,000	536,600	6	532,694	346,251
Cumberland, Md	3	204,900	187,855	3	210,000	189,000
Virginia and West Virginia	2	20,000	15,000	2	16,000	14,400
Georgia	1	40,000	40,000	1	37,000	36,260
Ohio	2	70,000	68,000	3	121,000	108,900
Illinois	2	409,877	276,931	2	370,000	307,000
Milwaukee, Wis	1	460,000	150,000	1	470,000	145,700
Louisville District, Kentucky and Indiana	11	1,513,009	983,456	11	2,142,782	964,252
Minnesota (Mankato)	1	101,875	76,406	1	105,000	78,750
Kansas City and Fort Scott, Mo. and Kan.	2	135,000	94,000	2	160,000	120,000
Utah (Salt Lake City)	1	5,000	10,000	1	5,000	10,000
Tennessee (Chattanooga)	1	33,100	36,026	0	....	....
Totals	63	7,607,067	5,512,153	62	8,132,593	5,549,163

* Not including one new mill, building.

PRODUCTION OF PORTLAND CEMENT, 1891 AND 1892.

	1891.§			1892.‖		
	Mills.	Barrels.	Dollars.	Mills.	Barrels.	Dollars.
Lehigh and Lawrence Counties, Pennsylvania	7	268,500	$532,850	6*	330,000	$610,500
Onondaga County, New York	5	87,000	290,000	6†	90,000	180,000
Ohio	2	35,000	82,000	4†	47,860	107,685
Indiana (South Bend)	1	15,000	36,000	1	15,000	33,750
Dakota (Yankton)	1	31,813	71,579	1	30,000	67,500
Colorado (Denver)	1	12,500	40,000	1	12,500	37,500
California	1	5,000	15,000	3‡	....	....
Illinois	....	....	....	1‡	....	....
Totals	18	454,813	$1,067,429	23	525,360	$1,036,935

* Including one new mill at Phillipsburg, N. J. † Including two new mills, not producing.
‡ New mills, not producing.
§ From *U. S. Mineral Statistics.* ‖ *Engineering and Mining Journal's Statistics.*

PRODUCTION OF HYDRAULIC CEMENTS IN THE UNITED STATES.

Year.	Natural.			Portland.			Total.	
	Barrels.	Price per Barrel.	Value.	Barrels.	Price per Barrel.	Value.	Barrels.	Value.
1880..........	....	....	... ...	....	....	....	2,072,943	$1,852,707
1881..........	....	....	....	....	....	....	2,500,000	2,000,000
1882..........	3,165,000	$1.10	$3,481,500	85,000	$2.25	$191,250	3,250,000	3,672,750
1883..........	4,100,000	1.00	4,100,000	90,000	2.15	193,500	4,190,000	4,293,500
1884.. ...	3,900,000	.90	3,510,000	100,000	2.10	210,000	4,000,000	3,720,000
1885...	4,000,000	.80	3,200,000	150,000	1.95	292,500	4,150,000	3,492,500
1886..........	4,350,000	.85	3,697,500	150,000	1.95	292,500	4,500,000	3,990,000
1887..........	6,692,774	.77½	5,186,900	250,000	1.95	487,500	6,692,744	5,674,377
1888..........	6,253,295	.72½	4,533,639	250,000	1.95	487,500	6,503,295	5,021,139
1889.........	6,725,000	.66⅙	4,450,000	275,000	2.00	550,000	7,000,000	5,000,000
1890...... ...	7,664,500	.69	5,295,950	335,500	2.10	704,050	8,000,000	6,000,000
1891..........	7,767,979	.72¼	5,613,522	454,813	2.34¾	1,067,429	8,222,792	6,680,951
1892..........	8,132,593	.68¼	5,549,163	525,360	1.97⅓	1,036,935	8,657,953	6,586,098

IMPORTS AND EXPORTS OF CEMENT.

Year.	Imports into United States.		Exports from United States.		Fiscal Years ending
	Barrels.	Dollars.	Barrels.	Dollars.	
1863................	a	a	a	a	June 30
1864................	a	a	a	86,386	"
1865................	a	a	a	94,606	"
1866....	a	a	a	a	"
1867................	a	a	a	a	"
1868	a	10,168	a	a	"
1869...............	a	9,854	a	a	"
1870................	a	18,057	31,175	61,490	"
1871................	a	52,103	27,575	51,585	"
1872................	a	172,339	39,686	69,218	"
1873................	a	209,097	27,873	52,848	"
1874	a	286,429	41,349	69,080	"
1875....	a	261,741	64,087	98,630	"
1876.	a	247,200	53,827	77,568	"
1877................	a	201,074	78,341	97,923	"
1878.....	a	184,086	82,507	98,334	"
1879................	a	212,719	60,657	74,097	"
1880...	a	373,264	41,[illegible]89	52,584	"
1881....	a	441,512	57,555	83,598	"
1882...........	370,406	683,684	67,030	100,169	Up to Dec. 31
1883................	832,996	1,321,225	109,113	177,531	calendar years
1884................	499,369	763,810	76,452	123,566	"
1885................	617,409	840,191	72,828	113,555	"
1886................	916,153	963,262	83,247	123,687	"
1887................	1,506,721	1,469,185	63,520	97,771	"
1888................	1,843,814	1,733,733	100,070	147,309	"
1889................	*1,745,624	1,705,100	89,995	142,298	"
1890........	*2,567,126	3,175,159	86,963	152,295	"
1891................	*2,991,236	4,411,330	83,607	130,371	"
1892................	*2,440,637	3,378,824	79,179	137,167	"

a. Not stated. * Custom-house returns for these years are given in pounds, which are reduced to barrels of 400 lbs. for convenience of comparison.

The statistics for 1892 compared with 1891 show an increase of production and a decrease of imports. The consumption for these years is as follows:

	1891.		1892.	
Total production....................................	8,222,792	barrels.	8,657,953	barrels.
Add imports..	2,991,236	"	2,440,637	"
	11,214,028	"	11,098,590	"
Deduct exports..	83.607	"	79,179	"
Apparent consumption..	11,130,421	"	11,019,411	"
Decreased consumption in 1892..			121,010	"

This may be slightly modified if stocks on hand at beginning and end of the year are taken into account. But makers carry practically no stocks of natural hydraulic cement, and the amount of American Portland carried over is always

small. The stock of foreign Portland cement in first hands at New York January 1, 1893, is reported at 65,000 barrels, against 100,000 barrels January 1, 1892.

Although the production of natural hydraulic cements shows an increase, yet the product is differently distributed. The Rosendale district, the chief producer, shows only a small increase. The most noticeable difference is in the Louisville district, where the product was increased from 1,513,009 barrels in 1891 to 2,142,-782 barrels in 1892, a gain of over forty per cent. Ohio shows an increase from 70,000 to 121,000 barrels. Decrease in manufacture of natural hydraulic cement is shown in the Lehigh Valley mills, from 695,000 to 532,694 barrels, or over twenty per cent.

It may be noted, in observing the change in distribution of manufacture, that the Louisville cements are very cheaply manufactured and have sold at 45 cents per barrel and even less; whereas the price of Lehigh Valley cements has averaged 65 cents at mill. One of the Lehigh Valley works refused to give figures of production, but the product could be closely estimated by the known capacity and comparison with neighboring works.

A review of the New York market for cements in 1892* shows a diminished local consumption, largely owing to strikes among workmen employed in building. This has been to a slight extent offset by a good demand for rail and steamer shipment to other localities in this country; and for export from mills supplying the local market, under the working of the reciprocity treaties.

Prices for exported cement have also averaged higher than in 1891. Supplies of natural hydraulic cement at the mills have been very closely cleaned out. Although manufacturers are somewhat doubtful as to the outlook for business in 1893, yet there is a decidedly hopeful feeling among dealers, owing to the expectation of large contracts for projected municipal buildings and other works of magnitude.

The production of American Portland cement shows a steady and gratifying increase from the time of its inception. Prices were fairly steady in 1892, although on the average lower than in 1891. Stocks at mills are reported as well cleaned out. This grade has participated in the export demand, chiefly to the West Indies: this appears in the higher average value of cements exported.

* In the *Real Estate Record and Guide.*

THE PROGRESS OF THE CHEMICAL INDUSTRY.

By Francis Wyatt, Ph.D.

In a series of essays published in the *Engineering and Mining Journal* in the year 1887 I made an effort to show that of all the arts which we had cultivated and improved, the manufacture of chemicals had made the least progress and received the least attention. This did not apply to our production of sulphuric acid, for which we were at that time consuming about 90,000 tons of imported brimstone and 100,000 tons of native and imported pyrites, and in which we were able to compare favorably, if not in cost, at least in practice, with that of the best in Europe.

The unfortunate circumstance that the great bulk of our acid was made from high-priced brimstone constrained us, however, to confine its use to the refining of petroleum or the manufacture of fertilizers, and none of it went into the production of alkali and soda salts. Our small output of these was derived either from the "ammonia" process or from the decomposition of cryolite; and as we were making no chlorine, or bleaching powder, the mass of our dyers, paper-makers, and glass and soap manufacturers were practically dependent upon our imports for the most essential elements in their raw materials. More than five years have elapsed since those essays were written, and although our general onward march in industry has been a rapid and triumphant one, so little change has taken place in this important branch that the picture then drawn might almost be used to represent it now.

Our manufacture of sulphuric acid has certainly increased, and we have kept abreast of the times by adopting many new appliances for the avoidance of waste and the lessening of cost. We have also, thanks to the energetic advocacy of Adams and other earnest workers, made substantial advance in the direction of pyrites consumption, and have thus placed ourselves on a more equal footing with European competitors. Beyond this we have done little worth recording, and have no reason for self-gratulation or complacency.

The American chemical trade has grown to be the prop and mainstay of the United Alkali Company of Great Britain! The American chemical industry is of proportions so insignificant as to be almost a negligible factor, and gives us no voice in fixing the market values for either alkali, soda salts, bleaching compounds, or dyes and coloring matters. Under these circumstances I shall not pause to review our own trade, but will give a photographic outline of the standing and progress of our purveyors.

Within the necessarily restricted limits of this article it is obviously impossible to deal with anything except practically successful achievements, and as the experiments in the domain of electricity do not yet come within that category, it is unnecessary to say more of them than that while the feasibility of manufacturing chlorine and caustic soda by the electrolysis of common salt has been fairly demonstrated, there is nothing at this moment before us to show that it can be done with commercial economy and regularity. When an inexpensive anode, that will stand the constant action of the nascent chlorine for a reasonable space of time, has safely undergone the test of practical work on the industrial scale, and when several thousand tons of bleaching-powder have been produced by the electrolytic method and sold in competition with other "makes," we shall be in a position to make real figures. Until then we can only wish success to the experimenters and their sanguine hypothesis, and must continue to base present calculations upon the actual developments of the two great processes which still monopolize our trade.

The Leblanc process, as it is now carried on, is based upon the decomposition of salt by sulphuric acid, the decomposition by coal and limestone of the sulphate of soda thus produced, and the partial recovery of the chlorine by Weldon's method. The alterations that have been made in its details have complicated rather than simplified its operations. The chief improvement of the past year has consisted in the adoption by many of the works of the Chance process, whereby about 80% of the sulphur that was thrown away as waste is recovered. This has had the effect of dissipating in a noteworthy measure the abominable nuisance hitherto created by the "waste," but from a financial point of view the success attained has not been as great as was at first anticipated. Chance sulphur certainly cannot compete for acid manufacture with the sulphur in Spanish pyrites at five dollars per ton, and can be made profitable only in the form of very pure brimstone to be sold in competition with the refined Sicilian product.

The improvement next in importance is the substitution of nitric acid for the Weldon manganese method of recovering chlorine; and while this has not yet been sufficiently tested to give reliable results, it may and probably will turn out to be very profitable. On the theory that "every little helps," these modifications will assist the Leblanc men in their bold struggle for existence, but the present complicated nature of their plant will not be lessened, nor will the costly item of labor be diminished. They will therefore be rendered none the less dependent than they now are upon their retention of the bleaching-powder monopoly.

The complex nature of the reactions entailed in the process may be partly gathered from the following equations:

Salt-cake and Hydrochloric Acid.—$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl$.

Soda-ash and Alkali Waste.—$Na_2SO_4 + 2CaCO_3 + 10C = Na_2CO_3 + CaS + CaO + 6CO$.

Recovery of Sulphur from Alkali Waste.—$2CaS + H_2O + CO_2 = CaCO_3 + H_2S$, and $H_2S + O = H_2O + S$.

Manufacture of Chlorine for Bleaching-powder.—$4HCl + MnO_2 = MnCl_2 + 2Cl + 2H_2O$.

Recovery of the Manganese.—$MnCl_2 + CaO = CaCl_2 + MnO$, and $MnO + O = MnO_2$.

In a large number of English and in some German works the sulphate of soda and hydrochloric acid are made by the Hargreaves-Robinson process, which I have formerly fully described and illustrated, and which dispenses with the preliminary and costly manufacture of sulphuric acid. The common salt is pressed into the form of bricks, and is then broken up and loosely packed in cylinders. Here it is brought to a dull-red heat and exposed to the action of steam, atmospheric air, and sulphurous acid, made by burning either brimstone or pyrites.

The following expresses the chemical reaction that takes place: $2NaCl + H_2O + O + SO_2 = Na_2SO_4 + 2HCl$.

Here, then, are the raw materials of the Leblanc process : salt, sulphur, coal, limestone, and manganese.

In the best practice half the chlorine and all the sodium of the salt, a large proportion of the sulphur, and some of the limestone are actually recovered and utilized. The plant is extremely costly and extensive, and is subjected to the severest possible wear and tear, while the process is attended by an inevitable creation of nuisances which desolate its surroundings. This being so, greatly as mankind is its debtor, few would regret to see it superseded by the more cleanly, simpler, and incomparably cheaper ammonia-soda process, to the development of which a number of our most intelligent chemists and engineers are continuously devoting their time and labors. Five years ago I explained that this process was handicapped by a "missing link." This missing link is an undiscovered industrial method of recovering even a portion of the chlorine in the common salt. Until this link is found the process must occupy a subordinate position, and the chlorine must continue to be sent down the sewers as waste calcium chloride.

The operations begin with a solution of brine, which is first saturated with ammonia gas (made from the destructive distillation of coal). It is next saturated with carbon dioxide (obtained from burning limestone or chalk). Bicarbonate of soda is thus formed and precipitated, and is separated from the solution of ammonium chloride. After being dried, it is sufficiently heated in a furnace to drive off one molecule of its carbon dioxide.

The ammonium chloride solution is, in the mean time, boiled with caustic lime, whereby the ammonia is set free and collected for future use, while calcium chloride is formed, and, having no value, is thrown away. Reduced to their simplest expressions, these reactions may be thus set down:

$NaCl + H_2O + NH_3 + CO_2 = NaHCO_3 + NH_4Cl$; $2NH_4Cl + CaO = 2NH_3 + H_2O + CaCl_2$; $2NaHCO_3 + \text{Heat} = Na_2CO_3 + H_2O + CO_2$.

This sodium monocarbonate, or soda-ash, is naturally of far greater purity than that made by the Leblanc process, and as it costs far less to make, it now supplies about half the consumption of the world. While it has no bleaching-powder to sell, however, when the demand for bleaching-powder continues so large,—or, in other words, while it has to compete with what may with perfect propriety be described as the by-product of the Leblanc bleaching-powder monopoly,—this seems to be as much as it can hope to accomplish.

It will be seen from this rough outline that the two processes have undergone no

very material commercial change since I last described them, and that they are still arrayed against each other in the same attitude of mortal combat. With the Leblanc it is a struggle for life ; with the ammonia-soda it is a struggle for supremacy. Everything that chemical ingenuity can suggest is being called into play, and neither party has left a stone unturned or an experiment untried. There have been many failures and a few partial successes on each side, but it is only within the past few months that both have made discoveries which promise to develop into something tangible. One of these discoveries, applied by Mond, is a cheap method of getting back all the chlorine now wasted in the production of ammonia-soda, and it has excited the curiosity and raised the hopes of industrial chemists the world over. The other, made by Gossage, promises to introduce into the Leblanc method modifications so remarkable as to revolutionize its practice, while lessening its manufacturing cost and vastly improving its products. While I have failed to obtain any figures on the financial results of the working trials of these two new methods, they both impress me as likely to play an important part in the near future.

The Mond chlorine-recovery process claims, of course, to break down the only barrier which remained to impede the progress of ammonia-soda, and, if it has really been made practicable on the industrial scale and is not so costly as it looks, it may soon be adopted in this country as well as in Europe.

Instead of being boiled with caustic lime, as it generally now is, the ammonia-chloride solution resulting from the decomposition of the brine is brought under the control of a powerful refrigeration apparatus, the extreme cold of which causes the crystallization of the ammonium chloride. After removal from the liquid the crystals are dried and vaporized. When the fumes of ammonium chloride are brought into contact with metallic oxides, chlorides are produced. This has led to the assumption that at high temperatures the hydrochloric acid and the ammonia are temporarily dissociated. Mond has acted upon this, and passes his hot vapors over a large surface of magnesium oxide. The magnesium oxide parts with its oxygen and unites with the chlorine of the hydrochloric acid to form magnesium chloride, while the oxygen enters into combination with the liberated hydrogen to form water. The ammonia in a perfectly free state passes on to receivers, and is stored for further use in the ordinary manner. In lieu of the waste chloride of calcium, therefore, there is thus obtained the less refractory magnesium chloride, which under certain conditions will, as we all know, readily part with its chlorine. The main difficulty however, is to realize economically the exact conditions required; for although Pechiney, Schloesing, and others have made many costly experiments in various ammonia-soda works, no industrial success has attended their efforts, and it is therefore at this stage of the process that the real ingenuity of the new method appears to come in. Nearly all previous efforts have aimed at recovering hydrochloric acid by treating the magnesium chloride with superheated steam; but Mond has abandoned the attack from that direction, and, availing himself of more recent discoveries, notably those of Schloesing, has approached the problem from another side. He simply reverses the operation by which his chloride was originally formed, displacing the chlorine by passing over it a current of hot air. The oxygen of this air reconstitutes the magnesium oxide, and the liberated chlorine passes along, in company with inert gas, into a series of chambers containing well-slacked lime. Here, of course, bleaching-powder, or $CaCl,OCl$, is produced.

The process is strictly scientific, but it is not yet out of the experimental stage, and will largely depend for success on the mechanical devices by which it is conducted. It would be premature and improper, therefore, to indorse the extravagant claims that are already made for it from the commercial standpoint. Theoretically, it promises to make the ammonia-soda operation a circular and perfect one, in which the only loss will be that of the coal used in the production of heat and power. Practically, it must furnish the proof that it can be applied without enhancing the cost of its soda, and make chlorine and bleaching-powder so cheaply as entirely to stifle the competition of its rival.

Gossage Alkali and Sulphur Recovery Process.—This recently perfected process for application to the old Leblanc or the more modern Hargreaves-Robinson method of making salt-cake may make this task of the ammonia-soda process less easy than it might have seemed a year ago.

Without interfering in any way with the chlorine-recovery or bleaching-powder manufacture as now carried out, its plan is to furnace the salt-cake with the necessary proportion of coal slack. The sodium sulphide thus produced is thrown into tanks, treated with a large quantity of water, and allowed to settle thoroughly. The supernatant liquid is drawn off and treated with sufficient carbon dioxide (made from burning limestone) to throw out any silica and alumina, and the clear solution of sodium sulphide and chloride is next conducted to towers, where it is treated with carbon dioxide in excess. The sodium sulphide is hereby decomposed, and bicarbonate of soda and hydrogen sulphide are formed. The bicarbonate is furnaced, carbon dioxide is recovered and stored for further use, and soda-ash is produced. The hydrogen sulphide is either burned to pure sulphur, which, like the Chance product, may be sold as such, or to sulphur dioxide, which may be used in the preliminary operation of decomposing the common salt.

The weak liquors which remain after the above treatment are used for lixiviating further quantities of the crude sulphide (black ash), or are evaporated to recover the salt and use it over again in the sulphating furnace.

The following equations will in some measure express the reactions involved:

$$Na_2SO_4 + 4C = Na_2S + 4CO\ ;\quad Na_2S + 2H_2O + 2CO_2 = 2NaHCO_3 + H_2S\ ;$$
$$2NaHCO_3 + \text{Heat} = Na_2CO_3 + H_2O + CO_2;\quad H_2S + \text{Heat} + 3O = H_2O + SO_2.$$

If the Gossage process were presented to us in its entirety as a new phase of the chemical industry, it would, unlike that of Mond, neither deserve nor receive much attention, on account of its circuitous nature and the complexity of its details. It does not come to us, however, in this guise, but is simply offered as an improvement whereby the manipulation of an antiquated method may be greatly simplified and cheapened. In this light one is impressed with its neatness and originality, and I am informed that it has withstood severe tests on the industrial scale, and is regarded by its owners as ready to pass at once into the domain of practical work.

The most suitable sulphate for its purpose is said to be one that contains about 20% of undecomposed sodium chloride. It is therefore highly probable that if it is ever generally adopted it will be preferably used in connection with the Hargreaves-Robinson process. Sulphuric-acid manufacture will thus be suppressed, and a very considerable economy in plant and labor will come at once under this head. Whether either Mond's or Gossage's process will come into general use, and how long they will constitute means for the two rivals to continue their

deadly duel, depends more upon engineering and mechanical successes than upon chemical reactions, but they may fairly be expected to bring out fresh developments, and probably to reduce prices during the coming year as the natural result of active and aggressive competition. Now comes the question whether we should continue to stand aloof as spectators of the fight for another year, or whether we should at once adopt either or both modified processes and try them for ourselves. They both appear feasible, but neither has yet furnished convincing evidence of its commercial superiority. There is naturally good cause for hesitation; but at the same time it is impossible for us to remain much longer in our present condition of indifference and inactivity, and it would be more worthy of us in every way if we were in the lists contributing our quota to the developments. If we went no further for the present, there is nothing to prevent us from manufacturing salt-cake and bleaching-powder; and if we commenced this at once, we should give great impetus to our glass and bleaching industries by cheapening the cost of their raw materials. We are in a position to produce them as well and as cheaply as they can be made anywhere else in the world; and the rapid increase in our population, the great growth of our requirements, and the consequent necessity for perfect self-reliance, makes it all the more incumbent upon us to do so. The cheapness of our coal, limestone, and salt is well shown in the following figures of comparison:

	Great Britain.		United States.	
	Production.	Value per Ton.	Production.	Value per Ton.
Coal	175,000,000	$1.00	150,000,000	$1.25
Salt	3,000,000	2.00	1,250,000	2.50
Limestone	....	1.50	....	1.50
Labor per man per day	....	.75	....	1.25

COST OF MANUFACTURING ONE GROSS TON OF SALT-CAKE AND BLEACHING-POWDER IN THE UNITED STATES.

Salt-cake.	Cost per Ton.	Bleaching-powder.	Cost per Ton.
Salt, .90 ton @ $2.50	$2.25	Lime	$3.50
Pyrites, .55 ton of 45% S. @ $4	2.20	Manganese	1.38
Coal, .40 ton @ $1.25	.50	Coal	1.83
Labor and waste	2.00	Powdered limestone	.30
Wear and tear of plant and sundries	.75	Labor and waste	3.50
		Casks	2.50
		Wear and tear	1.25
		Sundries	2.50
Total per gross ton	$7.70	Total per gross ton	$16.76

As the result of long and diligent inquiry in the proper quarters I am able to state that the average costs of manufacturing sulphate of soda and bleaching-powder in England are as follows:

Sulphate of soda or salt-cake, £1 10s., or $7.30, per ton of 2240 lbs.; bleaching-powder packed ready for shipment, £3 1s. 6d., or $15, per ton of 2240 lbs. The freight, insurance, and duty into this country probably amount together to at least 35% on these costs.

The production of soda-ash in the United States by the ammonia process has been as follows:

Year.	Tons.	Year.	Tons.	Year.	Tons.
1884	10,000	1887	35,000	1890	67,000
1885	15,000	1888	50,000	1891	72,000
1886	25,000	1889	55,000	1892	82,000

About two tons each of coal, salt, and limestone are used for each ton of soda-ash produced.

The Progress of Chemical Industry in Europe in 1892.

By Prof. Dr. George Lunge.

While up to this moment the manufacture of heavy chemicals is proceeding in the usual way, and the influence of the innumerable new processes brought out during the last few years is not yet felt in the market to any large extent, there can be no doubt that we are in a state of transition, and that great changes are impending which will probably revolutionize the alkali and chlorine industries. It becomes more and more apparent that the Leblanc process, to which the recovery of sulphur, according to Chance and Claus, seemed to have given a new lease of life, is not destined to rule much longer. Of course it will not die a sudden death. The immense capital invested in it, especially in Great Britain; the great practical experience of the Leblanc alkali-makers; and the difficulty of choosing among the new proposals, all of which call for very large pecuniary outlay, must necessarily retard the change; but it is inevitable, and may possibly be practically completed before the close of this century.

There is more than one quarter from which the death-knell of the Leblanc process is being sounded. The ammonia-soda manufacture had long ago established a decided superiority over it as a soda-making process; and everybody knows the enormous strides which it has made during the last decade, as well as the great profits even now realized by the various firms affiliated to the Solvay Company. But hitherto it was an undisputed fact that chlorine could not be economically made in connection with the ammonia-soda, in spite of numerous attempts in that direction. Now, however, we are somewhat sensationally informed that Mr. Ludwig Mond has overcome that task. By freezing out the ammonium chloride from the mother-liquors, subliming it, and passing the vapor over magnesia, he retains the hydrochloric acid in the shape of magnesium chloride, while the ammonia passes on in order to be used over again; the magnesium chloride is then submitted to the action of hot air, and is split up into chlorine and magnesia. It will be remembered that the late Walter Weldon and his friend Péchiney devoted to the decomposition of magnesium chloride by hot air years of unremitting attention, combined with the most skillful application of chemical engineering anywhere attained, but without meeting with a sufficient economical reward. Their labors are, of course, an immense aid to Mr. Mond, who has, however, so many other difficulties to grapple with before arriving at the stage of ammonium chloride that we may well doubt whether his process will stand the only test which we can acknowledge in matters industrial, viz., whether it will pay. It is certainly a fact that Messrs. Brunner, Mond & Co. are now regularly manufacturing bleaching-powder—is said to the amount of 25 tons per week; they are even extending their chlorine plant. But seeing that that prosperous concern can afford to throw away tens of thousands of pounds upon mere experiments, and to put a somewhat large expense in making chlorine against the enormous profit they now make on alkali, we cannot rush to the conclusion that their process is really destined to crush out of life every other way of making chlorine products. It may be so, but some little time must pass before we can be certain about it.

Supposing, however, that the Leblanc people are not to be killed by the blow threatening from that side, their doom is evidently sealed in another direction. After a long series of failures, some of the processes for making chlorine by electricity now seem to be securely established. We shall not discuss the question

which of them may be the best in the field; but it is certain that in some quarters all difficulties have been finally overcome, and that all other old or new chlorine processes will soon be out of favor. We poor Europeans may well tremble as we think of the enormous advantages for all applications of electricity enjoyed by the United States with their unbounded water-power, coal-fields, and oil-wells, not to speak of natural gas. In all human probability they will soon cease to be importers, and may even become exporters of bleaching-powder.

The electrical processes are certainly far greater sources of chlorine than of alkali. They produce from common salt for every ton of bleaching-powder only half a ton of soda-ash, or one third of a ton of caustic soda. The bulk of the alkali must therefore be supplied from other sources, undoubtedly at first principally in the shape of ammonia-soda. But here again the mineral wealth of the United States is evidently destined to prove fatal to the old processes. There can be no doubt that the immense quantities of "natural soda" shown by Dr. Chatard and other eminent members of the United States Geological Survey to exist in the Californian and other soda lakes will not be allowed to lie dormant any longer. If those lakes are once worked with the energy which is otherwise not wanting in America, the days are numbered when Liverpool soda will rule in the New York market.

The acid trade, which is having such enormous development in the United States, is comparatively quiet in Europe; hence the improvements proposed in that manufacture are making slow progress. The sulphuric-acid makers hesitate to embark more capital in that trade, seeing that many of their plants may become idle if the Leblanc soda-manufacture ceases. Not even the domain of hydrochloric acid is safe for them, for the Stassfurt magnesium chloride is a dangerous rival in that quarter. Only the nitric-acid manufacture is still extending, although not so rapidly as a few years ago, when a boom was created by the numerous smokeless powders and other new explosives. In that manufacture Guttmann's condensing apparatus is finding much favor, as it yields most of the acid at the maximum of strength and with a minimum of nitrogen peroxide.

The New York Heavy Chemical Market in 1892.

General Market.—Of all the markets probably none has been so devoid of speculative features and the disturbing element incident thereto as the market for heavy chemicals. For this we are indebted, primarily, to the formation nearly three years ago of the United Alkali Company, Limited, which, comprising as it does nearly all the chemical works in Great Britain, has been enabled to regulate almost absolutely the question of output and prices. Then came the appointment in 1891 of exclusive agents in this country and Canada for the sale of bleaching-powder. Ever since then, with the exception of a brief period during the late cholera scare, the trade in bleaching-powder has been of a routine character, as all large consumers were obliged to purchase their supplies from the agents, and the price did not fluctuate from week to week as formerly. In February of 1892 the exclusive agents were appointed in the United States for the sale of the United Alkali Company's caustic soda; thereafter the market for that important chemical lost all the elements of uncertainty as to prices and supplies which had before prevailed, and there has been no competition between the various dealers and brokers.

The demand and the volume of business generally have been up to expectations, slacking off somewhat at the end of the year on account of the excitement attend-

ing the Presidential election, as well as the customary falling off in business at the close of every year.

The table of prices on the following page shows that with the single exception of bleaching-powder there have been no great fluctuations in prices at any time during the year. In the case of that commodity the rise to 10c. in September was due to the cholera scare, which caused a great demand for it for disinfecting purposes. All the available supply on the spot was absorbed, and even after all fears of an epidemic were at an end a speculative tendency kept the price for goods on the spot higher than before. The standard price over 1893 promises to range about five per cent higher than the standard price for 1892.

Caustic Soda.—The imports of caustic soda during 1892 were lighter than those for 1891, and the output at Syracuse, N. Y., has increased. It is not probable that the consumption in this country has decreased, for it must be borne in mind that the surplus stocks remaining in the hands of dealers at the close of 1891 have entered into this year's consumption. A year ago at this time it would have been comparatively easy to buy 2000 or 3000 drums of foreign caustic soda on the spot. To-day it would be difficult, if not altogether impossible, to obtain 200 or 300. The nature of the trade in English caustic soda throughout the past year has been different from previous seasons, due, as before stated, to the appointment of agents for its sale in this country. Consumers have bought from hand to mouth only, having lost their fears of any sudden change in prices, and there has been no accumulation of stocks or lack of supplies at any time. Prices in 1892 have averaged from 2½% to 5% higher than in 1891. At the time of our going to press, prices for delivery over 1893 are from 5% to 7½% below the present range of figures for goods on the spot.

Carbonated Soda-ash and Alkali.—The importations of carbonated soda-ash into this country throughout 1892 have been smaller than in 1891. The Leblanc makers are at a disadvantage in making old process ash in competition with the ammoniated-alkali makers, and naturally the former have not pushed the production. The facility with which the United Alkali Company can regulate the output of any one product, increasing or decreasing it at will by decreasing or increasing the production of other chemicals, enables them to do this to great advantage. The market has been very quiet, and as early as last March the United Alkali Company announced that it would not sell any more Leblanc carbonated ash for delivery over 1892. On the other hand, the volume of business done in ammoniated alkali has been greater. Prices for this chemical have been gradually weakening, until at the close business for the delivery in 1893 has been done at 1.20@1.30c. for 58%. We understand that the production of alkali by the Solvay Process Company, of Syracuse, N. Y., has grown smaller in proportion as the production of caustic soda by the same works has increased. This is due, it is to be assumed, to the fact that proportionately alkali is not so highly protected by the McKinley tariff bill as is caustic soda.

Sal-soda.—The imports of English sal-soda have been shrinking, owing to the cheapness of the article and to the indisposition on the part of the English makers to compete with the American product on its own territory. For several years past the manufacture of sal-soda in this country has been growing. Many consumers manufacture it for their own use, using English soda-ash and ammoniated alkali as their raw material.

IMPORTS OF CHEMICALS.

Year.	Nitrate of Soda.		Bicarbonate Soda		Caustic Soda.		Sal and Ash Soda.		Other Soda Salts.		Nitrate of Potash.		Muriate of Potash.		Chloride of Lime.	
	Pounds.	Dollars.	Pounds.	Dollars	Pounds.	Dollars.	Pounds.	Dollars.	Pounds.	Dollars	Pounds.	Dollars	Pounds.	Dollars.	Pounds.	Dollars.
1867..	29,429,469	563,624	20,902,050	805,348	12,942,017	548,858	128,493,598	2,736,237	80,335	1,461	8,544,912	295,250	875,205	88,787	27,142,919	798,391
1868..	18,433,173	283,785	23,544,057	607,771	12,101,490	460,609	132,880,771	2,547,860	80,250	1,440	6,137,155	197,286	777,855	68,634	24,495,594	636,608
1869..	28,866,364	600,691	18,092,250	540,263	13,705,254	448,661	151,049,787	2,592,506	346,763	3,938	8,878,996	313,114	877,432	78,288	33,800,056	819,610
1870..	31,122,795	752,601	15,014,628	347,530	20,804,681	653,790	149,245,792	2,327,720	105,158	1,386	4,759,968	173,731	1,235,946	127,333	24,202,766	467,459
1871..	50,290,377	1,254,965	18,998,399	421,177	27,952,469	877,710	174,065,704	2,669,474	619,782	10,231	5,072,381	208,423	2,170,473	284,809	32,111,839	635,910
1872..	35,817,597	934,118	13,530,188	374,231	29,992,539	1,037,328	164,764,752	3,119,324	927,024	14,283	4,409,789	207,242	6,995,825	346,529	35,043,050	930,953
1873..	59,757,241	1,469,243	10,571,049	369,867	28,171,629	1,269,142	215,680,880	5,261,009	364,406	7,534	10,681,948	498,932	8,886,852	337,240	43,920,383	1,259,970
1874..	61,978,316	1,338,141	11,873,182	435,454	34,282,189	1,516,132	180,330,438	7,679,555	294,993	5,242	8,280,341	392,515	8,831,331	352,806	39,184,641	1,027,644
1875..	52,105,826	968,855	6,853,588	231,754	37,669,885	1,419,292	198,559,205	3,912,457	187,877	4,327	9,457,954	380,286	13,159,522	374,011	48,443,540	1,059,371
1876..	51,887,218	1,055,357	4,482,911	125,587	32,093,691	1,107,200	185,577,166	3,217,062	176,166	2,894	7,507,213	279,634	11,549,733	333,337	46,934,185	850,216
1877..	54,246,531	1,324,299	3,765,165	98,277	33,375,447	1,043,933	219,280,164	3,473,317	262,569	3,340	10,322,255	382,091	16,164,862	473,805	47,592,989	711,601
1878..	42,258,855	973,223	3,693,494	92,917	33,178,762	1,015,554	227,946,540	3,306,990	341,618	6,276	8,126,384	332,162	21,584,874	503,739	49,576,396	602,201
1879..	76,285,858	1,324,299	2,392,719	60,701	45,767,366	1,209,469	245,599,656	3,175,714	417,476	5,884	9,243,193	282,088	23,958,425	471,969	61,026,447	661,325
1880..	68,043,426	1,830,396	7,716,289	133,264	43,693,333	1,056,497	307,065,268	4,704,438	728,629	13,106	12,762,545	498,959	27,530,294	681,768	70,047,541	994,359
1881..	126,613,909	2,909,368	1,791,330	56,808	50,500,802	1,155,215	287,516,778	3,525,084	3,204,484	26,487	13,041,704	487,916	27,205,496	737,878	86,952,887	822,510
1882..	150,297,385	2,045,127	2,115,891	53,535	60,802,359	1,336,497	331,388,943	4,009,237	9,968,465	66,197	10,451,272	391,532	45,925,535	1,004,831	93,619,703	847,564
1883..	128,333,230	2,469,013	2,041,103	51,099	65,593,102	1,436,450	327,121,598	3,931,278	9,434,953	56,310	11,884,592	395,443	32,732,473	743,940	103,348,329	1,350,838
1884..	145,825,237	2,218,217	1,863,057	38,432	70,871,734	1,628,684	288,610,304	3,396,011	9,411,103	53,412	10,262,228	303,561	39,814,102	591,343	93,451,223	1,651,237
1885..	89,573,975	1,332,969	3,033,498	54,352	79,880,338	1,659,936	303,148,263	3,387,351	4,443,355	28,386	11,838,354	314,380	44,794,335	687,033	94,301,180	1,337,485
1886..	139,381,060	2,373,068	3,417,803	59,967	79,726,941	1,553,158	301,963,864	3,244,700	10,593,355	40,770	10,132,805	278,859	47,062,984	723,010	102,249,640	1,418,023
1887..	163,776,049	2,253,806	1,803,183	31,603	89,162,856	1,651,337	280,777,373	2,843,892	16,171,131	51,665	9,601,381	264,560	40,891,063	597,588	103,086,679	1,686,742
1888..	154,834,445	2,168,607	1,502,096	22,709	81,620,366	1,370,552	299,756,473	2,887,534	19,205,872	70,417	7,240,636	191,894	66,955,744	989,915	101,172,022	1,625,799
1889..	169,746,583	2,500,137	1,124,065	18,443	75,418,604	1,253,072	307,256,243	2,937,084	17,6‑6,879	98,353	9,822,848	270,008	68,059,738	1,015,263	96,571,074	1,517,402
1890..	293,007,228	3,090,900	916,355	16,962	88,345,462	1,882,728	360,521,656	4,176,422	21,664,033	132,443	13,563,798	408,460	63,773,938	978,024	105,696,046	3,314,548
1891..	219,712,640	2,579,930	1,500,663	26,936	68,154,226	1,700,532	347,822,902	4,509,611	16,226,334	114,955	15,292,057	469,591	78,144,810	1,220,119	108,880,831	1,632,127
1892..	213,456,320	2,933,174	(a)	(a)	54,331,533	1,337,013	361,672,150	4,699,473	(a)	(a)	13,012,087	382,771	70,227,971	1,098,267	109,888,561	1,962,084

NOTE.—Fiscal years from 1867, inclusive; calendar years from 1883, inclusive. (a) Not stated in 1892.

HIGHEST AND LOWEST PRICES OF HEAVY CHEMICALS IN NEW YORK IN 1892.

	January.		February.		March.		April.		May.		June.		July.		August.		September		October.		November.		Decemb r.		Aver-age.
	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	High.	Low	
Caustic soda, 60%....	3.20	3.10	3.10	3.00	3.25	3.10	3.25	3.10	3.20	3.17½	3.20	3.17½	3.20	3.15	3.20	3.17½	3.20	3.17½	3.20	3.17½	3.27½	3.17½	3.27½	3.17½	3.17½
" " 70–74%...	2.95	2.85	2.95	2.85	3.20	2.90	3.10	2.90	3.12½	2.95	3.12½	2.95	3.12½	2.95	3.12½	2.95	3.12½	2.95-	3.12½	2.95	3.15	2.95	3.15	2.95	3.01
" " 76%....	3.20	3.15	3.20	3.10	3.12½	2.92½	3.25	2.92½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.16
" " 77%....	3.00	2.90	3.00	2.87½	3.12½	3.00	3.25	3.05	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.25	3.12½	3.13
Carb. soda ash, 48%....	1.67½	1.55	1.62½	1.55	1.75	1.65	1.75	1.62½	1.75	1.55	1.60	1.50	1.60	1.52½	1.62½	1.52½	1.62½	1.55	1.60	1.35	1.60	1.55	1.60	1.55	1.60
" " " 58%....	1.60	1.50	1.55	1.50	1.62½	1.45	1.55	1.45	1.55	1.45	1.52½	1.45	1.52½	1.45	1.55	1.45	1.55	1.45	1.52½	1.45	1.52½	1.45	1.52½	1.45	1.50
Alkali, 48%...........	1.60	1.50	1.60	1.50	1.62	1.55	1.65	1.55	1.65	1.55	1.60	1.50	1.60	1.50	1.55	1.47½	1.85	1.50	1.65	1.50	1.55	1.47½	1.55	1.45	1.56
" 58%...........	1.50	1.40	1.52½	1.45	1.60	1.45	1.57½	1.45	1.55	1.45	1.52½	1.45	1.52½	1.40	1.50	1.40	1.75	1.45	1.55	1.45	1.50	1.40	1.47½	1.37½	1.48
Sal-soda, English..	1.15	1.10	1.15	1.05	1.12½	1.02½	1.15	1.02½	1.15	1.05	1.10	1.05	1.10	1.05	1.15	1.05	1.15	1.05	1.15	1.02½	1.10	1.00	1.05	.95	1.08
" " American...	1.00	.90	1.00	.82½	1.05	.90	1.00	.90	1.00	.90	1.00	.90	1.10	.97½	1.10	1.02½	1.10	1.02½	1.10	1.00	1.10	.95	1.00	.90	.98
Bleach..............	2.20	2.10	2.20	2.15	2.20	2.15	2.20	2.15	2.20	2.15	2.20	2.15	2.20	2.15	2.20	2.15	10.00	2.15	3.50	2.75	2.75	2.35	2.50	2.30	2.62

The Fertilizer Market in 1892.

In the fertilizer market 1892 has proved a better year than many anticipated. In the North the condition of the farmers generally has been satisfactory. In the South, where the bulk of the fertilizing chemicals is consumed, the year opened very inauspiciously. The decline in the price of cotton caused by over-production made money scarce, but affairs in that section have lately taken a decided change for the better. The cotton market has reacted from the very low figures which ruled last summer (when cotton reached 6c., while it is now in the neighborhood of 10c.), the cause being primarily the shortness in the crop, estimated this year at 6,500,000 bales, as against 9,000,000 in 1891. This means a vast amount of money to the South, and consequently a growing confidence in the ability of the farmers to pay.

The condition of the South Carolina phosphate trade continues depressed. Prices are almost unprecedentedly low, and barely cover the cost of production. The "combination" was broken up early in 1892, owing chiefly to the competition of the Florida rock. Many of the works in South Carolina and Florida have suspended operations, and with the continued low prices and the limited demand it would seem that many of the Western concerns must be forced to the wall.

The ammoniates have displayed a steadily advancing tendency for the past three or four months. The fish catch was very short. The production of fish-scrap this year is estimated at 13,000 tons, against 27,000 tons in 1891, 48,000 tons in 1890, and 52,000 tons in 1889. In addition to this, the shortness in ammoniated materials was further extended by the reduction in packing in the West. In November last there was a difference of about 1,000,000 in the number of hogs killed as compared with the same month in 1891. The yield of cotton-seed meal was greatly reduced by the failure of the cotton crop in some sections and the diminished planting through the entire cotton belt. The demand for such ammoniates as tankage and dried blood has been great, and prices have advanced rapidly. The following table shows the variations in prices during the year:

PRICE OF AMMONIATES FOR 1892.

	January 15.	March 15.	June 15.	September 15.	December 15.
Sulph. ammonia (bone)*	\$3.05@ 3.07½	\$2.95@ 3.00	\$2.80@ 2.85	\$2.87½@ 2.95	\$2.90 @ 2.95
Dried blood, high grade, per unit	2.00@ 2.05	1.80@ 1.85	1.80@ 1.85	2.00 @ 2.05	2.37½@ 2.50
" " low grade, " "	1.90@ 1.95	1.70@ 1.75	1 70@ 1.75	1.95 @ 2.00	2.30 @ 2.40
Azotine	2.00@ 2.05	1.80@ 1.85	1 80@ 1.85	1.95 @ 2.00	2.35 @ 2.45
Tankage, per ton	19.00@21.00	16.50@20.00	17.50@21.00	18.00 @22.00	22.00 @25.00
Bone meal	22.00@23.00	22.00@23.00	22.50@23.50	23.00 @25.00	23.50 @25.50
Acid fish scrap, f.o.b. factory	12.00@13.00	13.00@13.50	11.00@12.00	13.00 @14.00	No stocks.
Dried " " " "	22.00@23.00	23 00@24.00	21.00@22.00	23.00 @23 50	25.50 @26.50

* The gas liquor ruled from 2½@5c. higher.

In muriate of potash the volume of business during 1892 was smaller than for the preceding year, owing to the condition of affairs in the South. The reduced

imports of this salt show that the consumption has fallen off. Prices were fixed by the sales syndicate in January, and have not changed during the entire year. They ruled as follows for lots of 50 tons or over: New York or Boston, \$1.81½; Philadelphia or Baltimore, \$1.84; Southern ports, \$1.86½. Prices for 1893 on orders placed prior to Jan. 31 are as follows: New York or Boston, \$1.75; Philadelphia, \$1.77½; Southern ports, \$1.80. Prices on orders placed after Jan. 31 will be 3c. higher per 100 lbs.

There has been an increased consumption of double-manure salts, which is plainly shown in the steady increase of the imports. For the past three years the imports of double-manure salts have been as follows: 1890, 9450 tons; 1891, 8850 tons; 1892, 10,100 tons. The imports of high-grade sulphate of potash for the same time have been: In 1890, 3450 tons; 1891, 4150 tons; 1892, 5500 tons. The prices for these salts were also fixed by the syndicate, and have not fluctuated during the year. They ruled as follows: Double-manure salts, \$1.13½ per cwt., basis 48%@50%, in 50-ton lots, on foreign weights and analyses; high-grade sulphate, \$2.13 per cwt., basis 90%, foreign weights and tests. The price of double-manure salts for 1893, for orders placed prior to Jan. 31, has been fixed by the syndicate as follows: New York and Boston, \$1.10; Philadelphia, \$1.12½; Charleston and Savannah, \$1.15 per cwt., basis 48%@50% in 50-ton lots, on foreign weights and analyses. Sulphate of potash, 90–96%, basis 90%, New York and Boston, \$2.05; Philadelphia, \$2.07½; Charleston and Savannah, \$2.10. Sulphate of potash, 96–99%, basis 90%, is 4% higher. Prices on orders placed after Jan. 31 will be at the rate of 2c. per 100 lbs. higher on double-manure salt and 3c. per 100 lbs. higher on sulphate of potash. Buyers have the option of increasing the quantity by 25%, such option to be decided on or before Sept. 1, 1893.

Nitrate of Soda.

During the early part of the year, owing to the rumors of war with Chile, the nitrate-of-soda market advanced to \$2.10 for spot goods. There was but little speculation, however, consumers holding the opinion, subsequently justified, that there would be no serious trouble. A little later in the year a conference of the various nitrate companies was held in London, and it was agreed to restrict the exportations of nitrate during 1892 to 17,000,000 quintals (a quintal = 100 lbs.). This agreement has been adhered to, and it has induced a firmer feeling in the market.

Toward the close of the year the price commenced to advance. A speculative movement was set on foot by a firm which was reported to have bought a large portion of the stock on hand, as well as of the prospective supplies. This created some uncertainty as to the future, so that quotations for shipments were indefinite, dealers in many instances refusing to make any. During the last month or two the stocks on hand have been almost unprecedentedly small, owing to a series of accidents to several incoming nitrate-laden vessels.

The comparatively high price at which nitrate of soda has been selling of late has induced some gunpowder-makers to use Bengal saltpetre (nitrate of potash) instead of the Chilean article, after it has been reduced by means of the muriate

of potash. Yet as new powder-mills have been started which use nitrate of soda, and as the demand for other uses has not fallen off, but rather increased, the total consumption remains about the same as in 1891.

The following table shows the highest and lowest price per cwt. of nitrate of soda on the spot during 1892.

January.		February.		March.		April.		May.		June.	
Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
$2.10	$1.95	$1.90	$1.80	$1.95	$1.80	$1.85	$1.70	$1.70	$1.60	$1.70	$1.60

July.		August.		September.		October.		November.		December.		Average for year.
Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest	Highest	Lowest	
$1.75	$1.70	$2.00	$1.70	$2.00	$1.95	$2.12½	$1.95	$2.17½	$2.05	$2.20	$2.10	$1.88

Messrs. Mortimer & Wisner, the well-known nitrate brokers of this city, supply the following statistics:

	1885.	1886.	1887.*	1888.	1889.	1890.	1891.	1892.
Imported into Atlantic ports from west coast S. A., from Jan. 1, 1892, to Jan. 1, 1893...bags	270,613	386,718	481,505	478,751	484,555	688,124	632,536	641,165
Imported into Atlantic ports from Europe, "	....	11,984	....	.... .	....	....	18,802	5,862
	270,613	398,702	481,505	478,751	484,555	688,124	651,338	647,027
Stock in store and afloat Dec, 31, 1892, in N.Y. "	74,911	66,580	42,940	81.843	21,209	33,954	50.685	14,034
" " " " Boston, "	2,400	....	....	....	500	....	900	420
" " " " Philadelphia, "	.... ..	....	....	. .....	....	.. ..	... ...	... .
" " " " Baltimore, "	7,500	3,500	6,000	5,200	300	2,500	2,000	1,000
To arrive, actually sailed .... "	... ...	....	....	....	....	155,000	188,000	164,000
Visible supply to April 1, 1893....,........ "	....	....	... ...	....	....	191,454	241,585	179,454
Additional charters......................... "	72,500	235,100	213,000	217,500	373,374	367,046	210,000	210,500
Total supply, when shipped....... "	157,311	305,180	261,940	304,543	395,383	558,500	451 585	389,954
Stock on hand Jan. 1, 1892................ "	116,404	84,811	70,080	48,940	84,043	22,009	36,454	53,585
Deliveries December........................ "	16,442	18,232	22,982	11,451	33,430	46.573	36,098	35,280
Total yearly deliveries...................... "	302,206	413,433	502,645	440,648	546,589	673,679	634,207	685,158
Prices current, Dec. 31, 1892..................	$2.40	1.95@1.97½	2⅛c.	2⅜c.	$1.90	$1.70	$2.07½	$2.15

* Included in the deliveries of 1887 are 23,678 bags shipped to European ports.

The Acid Market in 1892.

For many years the acid trade has not been in so flourishing a condition as it is at present. There has been in this vicinity a steady consumptive demand which has nearly equaled the production. Whatever competition there has been among our makers has not been characterized by the bitterness that prevailed two or three years ago. All the manufacturers were fairly busy throughout the year, but the productive capacity of the acid plants in the United States has been increased little, if at all.

The manufacture of acid is co-extensive with so many other industries that it is difficult to estimate with any degree of accuracy the total yearly production. Statistics of this important industry are so meager as to be almost valueless.

The consumption of pyrites for acid-making purposes has increased and is increasing. The great uncertainty as to the course of the market for Sicilian brimstone and the high prices it reached discouraged acid-makers here, and to this, as well as to the improvements in the processes for utilizing pyrites, is due the growing popularity of the latter.

Prices have not changed much during the year under review. At the close, while practically no advance has been experienced, it has been easier to obtain the prices asked, and values have ruled steady.

PRICES OF ACIDS DURING 1892.*

	High.	Low.		High.	Low.
Muriatic acid 18°, per cwt.	$1.25	$0.85	Sulphuric acid 66°, per cwt. (pyrites).	$0.95	$0.70
" " 20° " "	1.50	0.90	Chamber acid, per ton of 2000 lbs. (brimstone)	10.00	8.25
" " 22° " "	1.75	1.25	Chamber acid, per ton of 2000 lbs. (pyrites)	8.50	5.25
Nitric " 36° " "	3.75	3.125			
" " 40° " "	5.50	3.75			
Sulphuric " 66° " " (brimstone).	1.75	0.90			

* In Connecticut, owing to the local fight and the competition between certain manufacturers, acids of all kinds have sold below the prices given in the table.

CHROMIUM.

CHROMIUM is not employed in the metallic state, but it enters into some important chemical reagents and pigments, and forms with steel a valuable alloy, which has great hardness and other properties that render it very suitable for stamp-shoes, dies, and many other purposes. The mineral chromite, or chrome iron ore, which is a mixture of the oxides of iron and chromium, is the universal source of chromium. When pure (FeO, Cr_2O_3) it contains 68% of chromic oxide; but magnesia (MgO) often replaces a portion of the FeO, and ferric oxide and alumina part of the Cr_2O_3, lowering the grade of the ore. About 50% chromic oxide is the general market standard.

Occurrence.—Chromite is always found associated with serpentine, scattered through that rock in irregular masses, which are sometimes of considerable size. Mines in southeastern Pennsylvania and the adjacent portions of Maryland were formerly important sources of the mineral, and led to the establishment of the chrome works at Baltimore, which have continued to be the center of the industry in the United States, though the original supplies of ore have long since been exhausted. Some ore has been produced at South Strafford, Vt., by the Elizabeth Mining Company, which is controlled by the owners of the Baltimore Chrome Works, but its output in 1892 was insignificant. Four men were employed during the year in sinking and drifting in the vein, but no stoping was done, though it is said that the mine is prepared to make a large output.

The only commercial source of chrome ore in the United States at the present time is California, where extensive areas of chrome-bearing serpentine are found on the flanks of the Sierra Nevadas and the Coast Range. The ore sent to market is derived chiefly from Placer, Shasta, Del Norte, and San Luis Obispo counties. The mining is carried on in a desultory manner, the greater part of the ore being quarried by farmers in dull times and sold to dealers in small lots, only one mine, the Pick and Shovel (near San Luis Obispo), being exploited systematically. Much of the chrome ore existing in California assays less than 47.5% Cr_2O_3, and has no commercial value at present, while many of the richer deposits are in localities whence the cost of transport to market is prohibitory. It is stated that no ore with less than 50% chromic oxide can be shipped from San Francisco, even at ballast rates, around Cape Horn in competition with ores from the Mediterranean.

Uses.—The chief use of chromite is the manufacture of bichromate of potash, a salt that is very extensively employed in calico-printing. It is also a basis for many pigments, such as chrome yellow, chrome orange, chrome green, and considerable quantities enter into the construction of some forms of electrical batteries. Both the bichromate and the chromate of potash are important chemical reagents. The corresponding salts of soda have been introduced in the last five years quite extensively. A relatively small proportion of the chromite mined enters into the production of chrome steel. As contrasted with common steel, this has great hardness, and is valuable for cutting-tools, for stamp-shoes and dies, for safes, etc. It is chiefly made in Brooklyn, N. Y.

Production.—Baltimore is the great center of the American bichromate manufacture. The firm of Jesse Tyson & Sons (Baltimore Chrome Works) for many years had a monopoly of the business, but within the last few years the salt has also been produced by the Kalion Chemical Company in Philadelphia. Large amounts of bichromate are annually imported in addition to the home product.

The imported ore used in the United States is derived chiefly from Asia Minor. The production of chrome ore in the United States and the imports of ore and manufactured products are given in the following table:

UNITED STATES: PRODUCTION AND IMPORTS OF CHROME ORE.

Year.*	Chrome Ore.				Chromate and Bichromate of Potash.		Chromic Acid.	
	Production.		Imports.		Imports.		Imports.	
	Long Tons.†	Value.	Long Tons.†	Value.	Pounds.	Value.	Pounds.	Value.
1867	....	....	....	....	875,205	$88,787	....	....
1868	....	....	....	....	777,855	68,634	....	....
1869	....	....	....	....	877,432	78,288	....	$3
1870	....	....	....	....	1,235,946	127,333	....	8
1871	....	....	....	....	2,170.473	223,529	....	5
1872	....	....	....	....	1,174,274	220,111	514	49
1873	....	....	....	....	1,121,357	178,472	922	276
1874	....	....	....	....	1,387,051	218,517	44	13
1875	....	....	....	....	1,417,812	183,424	45	22
1876	....	....	....	....	1,665,011	175,795	120	45
1877	....	....	....	....	2.471,669	264,392	13	10
1878	....	....	....	....	1,929,670	211,136	32	35
1879	....	....	....	....	2.624,403	221,151	....	....
1880	2,288	$27,808	....	....	3,505,740	350,279	5	3
1881	2,000	30,000	....	....	4,404,237	402.088	124	89
1882	2.500	50,000	....	....	2.449,875	261.006	52	42
1883	3,000	60,000	....	....	1,990,140	208.681	290	338
1884	2,000	35,000	2,677	$73,586	2,593,115	210,677	....	120
1885	2,700	40,000	12	239	1,448,539	92,556	....	39
1886	2,000	30,000	3,356	43,721	1,985,809	139,117	....	101
1887	3,000	40.000	1,404	20,812	1,722,465	120,305	....	5,571
1888	1.500	20,000	4,440	46,735	1,755,489	143.312	....	281
1889	2,000	30,000	5,474	50,782	1,580,385	137.263	....	2,974
1890	3.599	53,985	4,353	57,111	1,304,185	113,613	....	634
1891	1,372	20,580	4,560	108,764	755,254	55,897	634	203
1892	3,000	30,000	‡ 4,950	‡ 55,579	‡ 953,493	‡ 75,183	‡ 279	‡ 96

* The statistics of production are for calendar years; imports are given for calendar years since 1886, previous years ending June 30. † Long tons of 2240 lbs. ‡ For first nine months.

COAL AND COKE.

By Wm. B. Phillips.

(Tons used are of 2000 lbs. each.)

The earliest mention of coal in this country seems to be that of Father Louis Hennepin. He speaks of a coal mine, above Fort Crèvecœur, on the Illinois River, not far from the present city of Ottawa, Ill., 75 miles southwest of Chicago. He saw the coal as early as 1679, and in his description of the country, published in 1698, he says there are "mines of coal, slate, and iron." The existence of coal in Illinois may well have been known to the early French explorers in the middle of the seventeenth century, but it is highly probable that the mines referred to by Father Hennepin were not worked at all in his day or for 150 years afterward.

The existence of coal in Virginia was noticed by Col. William Byrd in 1701, in Ohio by Lewis Evans in 1755, and in Western Pennsylvania by Col. James Burd in 1759.

The Virginia deposits near Richmond were the first mines opened regularly in this country. Mining was begun there about the year 1750, and the coal was sold at Richmond in 1766 for 12d. (24c.) per bushel, and in 1789 at Philadelphia for 1s. 6d. (37c) per bushel of 76 lbs. The coal was exported, coastwise, in considerable quantity; but it was not until 1822 that reliable returns could be obtained. In this year the coastwise exports were 53,999 tons, and they rose in 1833 to 159,040 tons.

Prior to the war of 1812, and indeed for many years afterward, Virginia and Liverpool coals were an important article of merchandise in Philadelphia and Baltimore, New York and Boston. The disturbances to traffic brought on by that war, and the difficulty in securing even domestic coal, operated to develop the anthracite fields of Pennsylvania.

The discovery of anthracite coal in Pennsylvania was made about the year 1790, by a hunter named Philip Ginter, in the Mauch Chunk Mountains, near the present town of Summit Hill. The first shipment, or rather conveyance, of anthracite coal to Philadelphia was about the year 1800, when William Morris, owning land near Port Carbon, had some carried thither. But he was unable to interest any one in the matter, nor was Col. George Shoemaker more successful in 1812. This enterprising man had nine loads hauled from the vicinity of the

Centreville mines to Philadelphia in 1812, and had great difficulty in escaping the wrath of the people for attempting to sell "stone" as coal. He finally sold two loads to Mellon & Bishop, for use at their rolling-mill in Delaware County, and gave away the other seven. The next lot of anthracite to reach Philadelphia was a shipment of 27 tons on the Lehigh River from Mauch Chunk, made by Miner & Hillhouse, in August, 1814. It cost $14 a ton alongside the wharf at Philadelphia.

Anthracite coal, chiefly on account of the difficulty of kindling it, was not a favorite fuel in this country for twenty years after the first shipments were made, and it was not until 1834 that the shipments reached a total of 421,832 tons. It had to fight for its place here as well as in Wales, where it did not gain a foothold until 1813, and in France, where it was not used until 1814.

The price of foreign coal at New York in 1815 was $16.43 per ton, and in 1842, when the wholesale price of anthracite in Philadelphia was $3.79, foreign coal sold in New York for $5.11. Between 1816 and 1834 foreign coal sold at prices varying from $8 to $10 per ton at New York, which was below the price of anthracite in the early part of that period, but about the same as in the latter part.

According to the eleventh census (1890), the area of the coal-fields of the United States was 219,094 sq. miles, with California, Colorado, Montana, North Dakota, Oregon, Utah, Washington, and Wyoming still undetermined. The total area cannot fall short of 300,000 sq. miles, a district as large as the entire States of Texas and Indiana. The area as given, 219,094 sq. miles, is, however, not to be taken as representing the workable area. The coal over thousands of square miles that are included in the coal measures is not available, because of the thinness of the seam, the inferior quality of the coal, or the great depth at which it occurs. We have no means at present of knowing what proportion of the total area can be considered as available. A rough approximation may be given as 50,000 sq. miles, which would be one sixth of the whole area of 300,000 sq. miles. It is not likely that it exceeds this estimate. The bituminous coal-fields occupy 99.95% of the 219,094 sq. miles, or 218,095 sq. miles, and the anthracite fields 0.05%, or 999 sq. miles. So far as concerns the area covered the anthracite fields are insignificant, and yet they furnished 28.6% of the total amount of coal mined in 1892. Twenty years ago the production of anthracite coal was 49.2% of the total, and in 1860 probably 75%. The amount of bituminous coal produced per sq. mile of area in 1892 was 559 tons, as against 49,735 tons per sq. mile of area for anthracite. Practically all the anthracite coal has been and is still obtained from Pennsylvania. Rhode Island, Virginia and Colorado together do not produce 50,000 tons per annum.

Mr. John H. Jones, special agent on coal for the eleventh census, divides the coal-fields of the United States into the two grand classifications of Anthracite and Bituminous, and these into smaller groups. His table is given with some slight modifications, which, however, do not materially affect it.

ANTHRACITE.

New England Basin.—Area in sq. miles, 500; Rhode Island and Massachusetts.
Appalachian Region.—Area in sq. miles, 484; Pennsylvania and Virginia.
Rocky Mountain Region.—Area in sq. miles, 15; Colorado and New Mexico.

BITUMINOUS.

Appalachian.—Area in sq. miles, 64,395; Pennsylvania, Ohio, Maryland, Virginia (partly Triassic), West Virginia, Eastern Kentucky, North Carolina (wholly Triassic), Tennessee, Georgia, Alabama.

Northern.—Area in sq. miles, 7,000; Michigan.

Central.—Area in sq. miles, 48,000; Indiana, Illinois, Western Kentucky.

Western.—Area in sq. miles, 98,700; Iowa, Missouri, Nebraska, Kansas, Arkansas, Indian Territory, Texas.

Rocky Mountain.—Area in sq. miles unknown; North Dakota, Montana, Wyoming, Utah, Colorado, New Mexico.

Pacific Coast.—Area in sq. miles unknown; Washington, Oregon, California.

The total production of all kinds of coal from 1870 to the close of 1892 in the several regions is given below.

In determining the amount of anthracite coal produced during this period the production outside of Pennsylvania has been taken at 350,000 tons, which includes the output of the New England Basin, Virginia, Colorado, and New Mexico, or an average for the twenty-three years of 15,217 tons per annum. The value of the coal at the mines has been taken at $1.50 per ton for anthracite, and $1 per ton for bituminous.

ANTHRACITE.

561,627,269 tons; value, $842,440,903.

BITUMINOUS.

Appalachian Region.—933,909,305 tons; value, $933,909,305.
Northern Region.—1,455,289 tons; value, $1,455,289.
Central Region.—254,821,177 tons; value, $254,821,177.
Western Region.—138,470,000 tons; value, $138,470,000.
Rocky Mountain Region.—53,848,504 tons; value, $53,848,504.
Pacific Coast Region.—12,313,040 tons; value, $12,313,040.
A total of 1,956,444,584 tons; value, $2,237,258,218.

The Appalachian region is not only the great anthracite region of the country; it is also by far the greatest producer of bituminous coal. The output of the different regions per sq. mile of area since 1870 is as follows:

Appalachian	14,503	tons.
Northern	208	"
Central	5,309	"
Western	1,403	"

The Central and Western regions, however, are rapidly increasing their output per sq. mile, for in 1870 the Central region produced 65 tons per sq. mile of area and the Western region 9 tons. In 1880 the Central region produced 140 tons and the Western 41 tons per sq. mile of area; and in 1892 the amounts were, respectively, 474 tons and 118 tons.

The increase in the Central region since 1870 has thus been from 65 to 474 tons, or 630%, and in the Western region from 9 to 118 tons, or 1211%.

The increase in the Appalachian bituminous region during the same period was from 201 to 1226 tons, or 510%. It is not at all improbable that the Central and

Western regions will continue to show a greater increase in the output per sq. mile of coal area, consequent upon the growth of population and the extension of the railway systems.

The output of the States in tons per square mile of coal area in 1870, 1880, 1890, and 1892 is as follows:

OUTPUT IN TONS PER SQ. MILE OF COAL AREA.

	1870.	1880.	1890.	1892.
Alabama	1.27	43.9	472.3	609.1
Arkansas	....	4.9	43.9	81.2
Illinois	70.7	121.1	412.8	481.1
Indiana	62.5	240.0	472.2	472.8
Indian Territory	....	.....	43.4	50.2
Iowa	14.6	94.0	223.4	212.2
Kansas	1.9	32.3	148.0	164.3
Kentucky	10.7	80.0	177.4	215.7
Maryland	3,309	4,895	6,105	7,338
Michigan	4.0	18.4	10.7	10.0
Missouri	23.1	62.5	90.6	112.1
North Carolina and Georgia.	.....	38.6	82.2	59.5
Ohio	252.7	784.0	132.0	145.6
Pennsylvania	2,472	5,011	9,360	9,612
Tennessee	2.6	140.7	476.4	473.2
Texas	....	.....	41.0	66.6
Virginia	28.3	57.3	359.0	366.1
West Virginia	38.7	87.7	375.2	544.4

The following tables give the area of the coal measures, total production, capital invested, employees, wages, costs per ton, and price (value) at the mines in the several States and Territories for the tenth and eleventh census years. It is to be noted that the area of the Pennsylvania anthracite has been increased by 14 sq. miles, by the Commission on Anthracite Coal Waste, since the census report of 1890 was issued.

COAL IN THE UNITED STATES: AREA, PRODUCTION, CAPITAL INVESTED, EMPLOYEES, WAGES, AND COSTS.—10TH CENSUS, 1880.

(1 ton = 2000 lbs.)

States.	Bituminous.			Employees.						Cost per Ton.			Value at Mines.
	Area in Sq. Miles.	Total Production.	Capital Invested.	Above Ground.		Below Ground.		Total Number.	Total Wages.	Wages.	Supplies.	Total.	
				Men.	Boys.	Men.	Boys.						
BITUMINOUS.		Tons.	$						$	cts.	cts.	$	$
Alabama	8,660	323,972	772,858	625	17	850	21	1,513	328,788	101	15	1.16	1.47
Arkansas	9,043	14,778	15,600	22	8	98	2	130	20,850	141	7	1.48	2.27
Cal. & Oregon	....	280,155	1,465,954	106	.. ...	713	8	827	389,967	139	18	1.57	2.72
Colorado	....	462,747	5,939,250	301	......	1,133	......	1,434	714,714	154	24	1.78	2.25
Illinois	36,800	6,115,347	10,654,261	2,152	71	13,128	950	16,301	6,035,919	99	11	1.10	1.43
Indiana	6,450	1,454,327	2,304,720	570	7	3,748	171	4,496	1,405,164	97	19	1.16	1.48
Iowa	18,000	1,461,116	2,778,937	808	12	3,994	210	5,024	1,554,696	107	17	1.14	1.72
Kansas & Neb	20,000	771,642	768,494	288	6	3,147	181	3,622	759,180	99	6	1.05	1.96
Kentucky	13,000	946,288	1,968,537	679	67	1,958	122	2,826	687,474	73	12	0.85	1.20
Maryland	550	2,228,917	13,165,557	505	37	2,660	475	3,677	1,370,079	61	8	0.69	1.16
Michigan	6,700	100,800	66,800	51	1	295	65	412	146,000	144	8	1.52	2.22
Missouri	26,887	844,304	389,315	253	12	2,096	238	2,599	642,772	118	12	1.30	1.96
Montana	....	224	12,550	......	......	3	.....	3	400	178	*a*	*a*	3.57
N. C. & Georgia	2,900	154,994	481,915	258	1	187	......	446	85,479	55	6	0.61	1.49
Ohio	10,000	6,008,595	13,652,484	1,852	98	13,626	755	16,331	5,100,587	86	16	1.02	1.29
Pennsylvania	9,000	18,425,163	39,822,114	4,509	308	26,560	2,070	33,448	10,929,583	64	9	0.73	1.01
Tennessee	5,100	495,131	1,708,968	242	95	693	62	1,092	336,765	68	9	0.77	1.29
Utah	.... ..	14,748	....	12	.....	79	......	91	25,675	160	18	1.78	2.28
Virginia	2,180	40,520	329,000	124	24	112	1	261	71,447	176	29	2.05	2.29
Washington	....	145,015	335,421	65	......	103	......	168	143,754	99	15	1.14	2.68
West Virginia	16,000	1,829,844	5,750,674	924	31	3,370	172	4,497	1,298,316	72	14	0.86	1.10
Wyoming	....	589,595	726,398	149	......	860	......	1,009	579,566	98	0.2	0.98	1.85
Total & average.	191,270	42,708,222	103,108,807	14,495	795	79,413	5,504	100,207	32,627,175	78	11	0.89	1.25
ANTHRACITE.													
Pennsylvania	470	28,640,819	154,399,796	16,073	12,181	38,465	3,950	70,669	22,664,055	79	24	1.03	1.47
R. I. & Virginia	500	8,993	104,540	27	......	51	.... .	79	29,352	334	35	3.69	2.65
Total average	970	28,649,812	154,504,336	16,100	12,181	38,516	3,950	70,748	22,693,407	79	24	1.03	1.47

(*a*) Not reported.

COAL IN THE UNITED STATES: AREA, PRODUCTION, CAPITAL INVESTED, EMPLOYEES, WAGES, AND COSTS.—11TH CENSUS, 1890.

(1 ton = 2000 lbs.)

State.	Bituminous.			Total.		Costs per Ton of Coal.								Price at Mines.
						Wages.								
	Area in Sq. Miles.	Total Production.	Capital Invested.	Employees.	Wages.	Above Ground.	Below Ground.	Office.	Total.	Contract Work.	Supplies and Materials.	Other Expenses.	Total Cost.	
BITUMINOUS.		Tons.	$		$	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$	$
Alabama	8,660	3,572,983	12,535,194	6,975	3,267,857	9	79	3	91	1	7	4	1.03	1.11
Arkansas	9,100	279,584	1,289,751	686	252,679	14	75	1	90	...	14	6	1.10	1.42
California & Ore. .	....	184,179	526,750	419	248,449	26	104	4	134	9	31	24	1.98	2.36
Colorado....... ...	... ..	2,544,144	12,611,849	4,872	2,724,800	18	87	3	108	4	20	11	1.43	1.54
Illinois.............	37,000	12,104,272	17,630,351	24,323	8,694,347	8	62	2	72	0.2	8	6	0.86	0.97
Indiana	7,000	2,845,057	3,435,703	6,532	2,201,044	9	66	2	77	0.2	9	5	0.91	1.02
Indian Territory...	20,000	752,832	1,492,009	1,873	927,267	11	110	2	123	3	7	23	1.56	1.76
Iowa.......	18,000	4,095,358	6,279,179	9.384	3,956,788	10	85	2	97	2	8	8	1.15	1.33
Kansas & Nebraska	20,200	2,222,443	3,488,539	6,069	2,320.588	10	91	3	104	0.3	12	6	1.22	1.49
Kentucky....... ...	14,000	2,399,755	6,581,380	5,260	1,756,363	10	59	4	73	2	10	5	0.90	0.99
Maryland	550	2,939,715	18,025,367	3,741	1,730,687	5	53	1	59	0.2	7	4	0.70	0.86
Michigan	7,000	67,431	49,650	265	93,594	31	103	5	139	....	13	16	1.68	1.71
Missouri	26,900	2,557,823	3,992,293	6,730	2,538,273	8	89	2	99	1	7	4	1.11	1.36
Montana	....	363,301	1,153,076	857	587,538	33	125	3	161	1	14	2	1.78	2.42
New Mexico	....	487,463	995,717	1,028	604,543	18	102	4	124	2	21	13	1.60	1 79
N. Carolina & Ga...	2,900	226,156	724,500	733	265,464	47	68	2	117	22	46	3	1.88	1.43
North Dakota......	....	28,907	66,580	76	18,460	10	50	4	64	....	10	1	0.75	1.43
Ohio............. .	10,000	9,976,787	14,018,236	19,591	6,892,604	7	60	2	69	0.6	6	7	0.82	0.94
Pennsylvania	9.000	36,174,089	53,322,330	53,712	20,738,647	3	53	1	57	8	7	7	0.79	0.77
Tennessee	5,100	1,925,689	4,362,711	4,108	1,609,310	8	72	3	83	0.6	14	12	1.09	1.21
Texas..............	4,500	128,216	307,335	549	256.834	35	162	3	200	...	43	10	2.53	2.66
Utah...............	....	236,651	844,560	565	268,570	14	95	4	113	2	28	2	1.45	1.59
Virginia	2,185	865,786	1,055,516	1,555	621,266	18	52	2	72	0.1	5	2	0.79	0.93
Washington	....	1,030,578	3,186,441	2.695	1,747,080	31	133	5	169	1	28	20	2.18	2.32
West Virginia	16,000	6.231,880	10,508,050	9,952	3,888,712	8	53	2	63	1	7	7	0.78	0 82
Wyoming	......	1,388,947	2,239,252	2,692	1,553,947	17	94	1	112	0.6	16	3	1.31	1.26
Total and average	211,095	95,961,595	180,722,319	175,242	69,765,711	16	84	3	103	2	15	8	1.28	1.43
ANTHRACITE.														
Pennsylvania	484	45,544,970	161,784,473	124,203	39,278,355	24	61	1	86	5	24	19	1.34	1.58
Colorado, New Mexico & Rhode Island	515	55,517	251,137	107	86,862	....	....	....	....	....	....	...	....	....
Total and average	999	45,600,487	162,035,610	124,310	39,365,217	24	61	1	86	5	24	19	1.34	1.58

As regards bituminous coal, the table of the census volume for the year 1890 shows a very curious discrepancy between the cost of mining and the value at the mines.

In North Carolina and Georgia (taken together) and Pennsylvania and Wyoming the total cost per ton was greater than the value of the coal at the mines. This difference for the first-named States is 45c., the cost being $1.88 and the value $1.43; for Pennsylvania the difference is 2c., the cost being 79c. and the value 77c.; for Wyoming the difference is 5c., the cost being $1.31 and the value $1.26. If this statement be true, then the output of these States, amounting in the census year 1890 to 37,789,192 tons, or 27% of the total output, was mined at a loss. If we consider the State of Pennsylvania in the census years 1880 and 1890, we find that the cost of mining bituminous coal in the former year was 73c. per ton, of which the wages comprised 64c., or 87.7%; and in the latter year the cost was 79c., of which the wages comprised 57c., or 72%. So that between these two decades the cost of mining had increased 6c. per ton, while the wages had decreased 7c. per ton. The value of the coal at the mines in 1880 was $1.01 per ton, leaving a margin of profit as between cost and value of 28c. per ton. In 1890 the cost was given at 79c. and the value at 77c. per ton. If these figures be true,

they would indicate that there had been during the decade a loss in value of 24c. per ton, which on the output of 1880 is a loss of $4,422,039, and on the output of 1890 of $8,681,781.

Taking the production of the entire country in 1880 at 42,708,222 tons and the value per ton at the mines at $1.25, we have for the total value $53,385,277. The production in 1890 was 95,961,595 tons, valued at $1.43 per ton, or a total value of $137,225,080. While the country at large increased the value of its output by $83,839,803, Pennsylvania, by far the largest single producer, shows a gain in value of only $9,244,634. In other words, for every dollar of value at the mines in 1880 the country at large had $2.57 in 1890, while Pennsylvania had $1.49. If Pennsylvania be excluded from the calculation, it is found that for every dollar of value at the mines in 1880 the rest of the country had $3.14 in 1890.

According to the census of 1880, the cheapest coal was mined in Georgia,—as North Carolina mined no coal then,—at 61c. per ton, Maryland taking the first place in 1890 with 70c. per ton.

Of the States which mined over 500,000 tons in 1880, viz., Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Missouri, Ohio, Pennsylvania, West Virginia, and Wyoming, the cheapest coal was mined in Maryland at 69c. per ton. To these eleven States were added six others by 1890, Maryland still holding the first place among the seventeen with 70c. per ton. The present cost of mining coal in Maryland is not far from these figures.

On the whole the census figures are not reliable, but they are reproduced here because they afford a basis of comparison as between the States.

The following table gives the production of coal by States and Territories from 1870 to the close of 1892. In compiling these figures the reports of the State inspectors have been followed in most cases, and various other sources of information have been consulted to make the table as accurate as the present condition of things will allow. It is not claimed that in every particular it is absolutely accurate, for some of the figures had to be estimated; but it is claimed that so far as available information goes it is sufficiently accurate for all practical purposes. The production which it was necessary to have estimated is very small as compared with the production made up from official reports. The production of anthracite coal in Pennsylvania in 1892 was obtained by adding six per cent to the shipments, as reported by the bureau of anthracite statistics, and is shown in the following table.

As to the cost of mining coal in the United States, the elaborate statistics gathered by the Hon. Carroll D. Wright, U. S. Labor Commissioner, afford the only authoritative general information. The table that follows has been prepared from Mr. Wright's report, and is limited to the cost of mining bituminous coal during the period intervening between the years 1888 and 1890.

The cost of producing coal as there given is in excess of that at some favorably situated and economically managed collieries in several of the States—coal being produced even below 40 cents a ton in at least one case, and at 50 to 55 cents a ton as the average of such districts as the Pocahontas in Virginia, where it is sold with a liberal profit at 75 cents a ton delivered on the railroad.

UNITED STATES PRODUCTION OF COAL FROM 1870 TO 1892 BY STATES AND TERRITORIES.

Tons of 2000 lbs.

Year.	Alabama.	Arkansas	California.‡	Colorado.	North Dakota.	Georgia.	Indiana.	Indian Territory.	Illinois.	Iowa.	Kansas.	Kentucky.	Maryland.	Michigan	Missouri.
1870*.	10,999	....	129,629	4,500	....	....	437,870	....	2,624,163	263,487	32,939	150,582	1,819,824	28,150	621,930
1871..	20,000	....	135,285	15,860	....	....	600,000†	....	2,700,000	340,000	35,000	250,000	2,627,691	25,000†	650,000
1872..	30,000	560	164,704	68,540	....	....	800,000†	....	3,000,000	300,000	40,000	340,000	2,555,500	30,000	700,000
1873..	44,800	2,240	150,378	69,977	....	....	1,120,000	....	3,920,000	392,000	200,000†	336,000	2,971,852	20,000†	784,000
1874..	50,400	5,600	240,035	87,372	....	40,000	909,440	....	3,360,000	560,000	280,000	403,200	2,700,202	13,440	799,680
1875..	67,200	10,080	186,030	98,838	....	50,000	896,000	....	3,920,000	1,120,000	308,000	560,000	2,623,905	13,440	840,000
1876..	112,000	15,780†	172,201†	117,666	....	62,000†	1,064,000	....	3,920,000	1,680,000	368,000†	738,000	2,355,290	35,000†	1,008,000
1877..	196,000	23,480†	158,372†	160,000	....	75,000†	1,120,000	....	3,920,000	1,680,000	428,000†	952,000	2,063,259	69,197	1,008,000
1878..	224,000	29,190†	144,543†	200,630	....	87,000†	1,120,000	....	3,920,000	1,680,000	488,000†	100,800	2,180,840	85,322	1,008,000
1879..	280,000	36,900†	130,714†	322,732	....	100,000†	1,340,068	....	3,920,000	1,792,000	528,000†	1,120,000	2,238,393	82,015	1,008,000
1880..	380,000	44,610†	116,885†	375,000	....	112,000†	1,680,000	....	4,480,000	1,792,000	550,000	1,120,000	2,692,497	129,053	1,680,000
1881..	420,000	47,000†	103,055	706,744	....	120,000†	1,984,120	....	6,720,000	3,920,856	750,000	1,232,000	2,833,348	130,130	1,960,000
1882..	896,000	50,000	113,255	1,061,479	....	130,000†	2,213,646	....	11,017,069	3,502,236	750,000	1,456,000	2,025,321	135,339	2,240,000
1883..	1,568,000	50,000	76,162	1,220,593	....	140,000†	3,072,000	....	12,123,456	4,457,540	900,000	1,848,000	2,476,075	71,296	2,520,000
1884..	2,240,000	75,000	77,485	1,130,024	35,000	150,000	2,531,200	....	12,208,075	4,370,566	1,552,154	1,736,000	2,765,617	36,712	2,800,000
1885..	2,492,000	100,000	71,615	1,398,796	25,000	150,000	2,375,000	500,000	11,834,459	4,012,575	1,440,057	1,904,000	2,833,337	45,178	3,080,000
1886..	1,800,000	125,000	100,000	1,436,211	25,955	223,000	3,000,000	534,580	11,175,241	4,315,781	1,390,000	1,550,000	2,517,577	60,434	2,800,000
1887..	1,950,000	129,600	50,000	1,791,735	21,470	313,000	3,217,711	685,911	12,423,066	4,473,829	1,570,079	1,933,185	3,278,023	71,461	3,209,916
1888..	2,900,000	276,871	95,000	2,185,477	34,000	180,000	3,140,979	761,986	14,328,181	4,952,440	1,700,000	2,342,059	3,479,470	81,407	3,909,967
1889..	3,572,983	279,584	121,820	2,400,629	28,907	225,000	2,845,057	752,832	14,017,298	4,095,358	2,152,766	2,205,417	2,939,715	67,431	2,223,477
1890..	4,090,409	399,888	110,711	3,075,781	30,000	228,000	3,305,737	869,229	15,274,727	4,021,739	2,516,054	2,483,144	3,357,813	74,977	2,437,399
1891..	4,759,781	542,379	93,301	3,512,632	30,000	171,000	2,973,474	1,091,032	15,660,698	3,825,495	2,753,724	2,916,069	3,820,239	80,307	2,650,018
1892..	5,314,227	739,300	131,431	3,771,234	240,000	165,000	4,494,811	1,004,765	17,949,989	3,820,000	2,794,000	3,020,050	3,036,283	70,000	3,017,285
1893..	5,170,042	750,000	167,219	3,947,056	325,000	372,191	4,583,000	1,229,562	18,955,000	3,790,000	2,590,700	3,290,032	3,727,079	104,620	3,285,000

Year.	Montana.	New Mexico.	Ohio.	Oregon.	Pennsylvania. Bit.	Pennsylvania. Anthr.	Tennessee.	Texas.	Utah.	Virginia.	West Virginia.	Washington.	Wyoming.	Total.
1870*.	....	....	2,527,284	....	7,798,517	15,650,275	133,418	....	5,800	61,802	618,878	17,844	50,000	33,003,315
1871..	....	....	2,478,185	....	8,909,584	19,464,877	150,000	....	15,000†	75,000	650,000	20,000†	147,328	39,308,810
1872..	....	....	5,953,129	....	10,442,000	24,734,172	200,000	....	20,000†	89,688	700,000	23,000†	221,745	50,410,038
1873..	....	....	5,096,031	....	13,098,829	25,626,631	392,000	....	25,000†	80,000	672,000	26,000†	259,700	55,100,938
1874..	....	....	3,659,395	48,384	12,320,000	24,267,472	392,000	....	33,600	81,872	1,120,000	30,352	219,061	51,637,005
1875..	....	....	5,447,970	32,256	11,760,000	23,120,730	403,200	....	38,800	88,704	1,120,000	99,568	300,808	53,121,029
1876..	....	....	3,920,000	30,000†	12,880,000	20,721,132	616,000	....	59,000†	97,888†	896,000	110,342†	334,550	51,328,217
1877..	....	....	5,880,000	35,000†	14,000,000	23,327,560	504,000	....	80,800†	107,072†	1,120,000	120,896†	342,853	57,371,989
1878..	....	....	6,120,000	40,000†	15,120,000	19,717,893	420,000	....	102,600†	116,256†	1,120,000	131,660†	333,200	54,505,434
1879..	....	....	6,720,000	42,000†	16,240,000	29,279,811	504,000	....	124,400†	125,440†	1,400,000	142,666	400,991	68,189,630
1880..	....	....	7,840,000	45,000†	21,280,000	26,249,711	717,967	....	146,200†	125,440	1,404,008	144,315	527,811	73,647,997
1881..	....	....	9,212,000	40,000†	22,400,000	31,920,018	840,000	....	168,000†	125,440	1,803,984	167,554	628,181	88,247,430
1882..	....	157,092	10,584,000	41,000†	24,640,000	32,614,507	952,000	....	190,800†	125,440	2,416,960	177,340	707,764	98,202,748
1883..	19,695	211,347	9,216,960	43,000†	26,880,000	35,418,353	1,120,000	....	195,000†	282,240	3,132,222	244,990	779,689	108,082,118
1884..	80,376	220,557	8,568,069	45,000†	28,000,000	36,558,478	1,344,000	....	200,000†	336,000	3,249,839	166,936	902,620	110,395,208
1885..	86,440	306,202	8,754,120	50,000	26,000,000	38,335,973	1,612,800	150,000	213,120	567,000	3,369,061	380,250	807,328	112,609,811
1886..	49,846	271,285	9,447,436	45,000	27,094,501	39,035,446	1,920,004	100,000†	200,000	684,951	3,598,664	423,525	829,355	114,660,292
1887..	10,202	508,034	11,537,912	31,696	31,516,856	42,088,196	2,128,000	75,000	180,021	825,263	4,936,820	772,601	1,170,318	130,975,305
1888..	41,467	626,665	12,220,259	75,000	33,796,727	46,619,564	2,203,372	100,000†	258,961	1,073,000	5,375,564	1,215,750	1,481,540	145,470,206
1889..	363,301	486,943	12,216,271	64,359	36,174,089	39,656,635	2,156,771	128,216	236,651	865,786	5,405,172	1,030,578	1,388,276	138,116,702
1890..	517,477	375,777	13,203,522	61,514	42,302,173	46,468,640	2,429,935	184,440	318,159	784,011	6,002,800	1,263,689	1,870,366	156,073,611
1891..	541,861	462,328	14,616,209	51,826	42,788,490	50,665,431	2,703,319	172,100	371,045	736,399	8,155,201	1,056,249	2,327,841	169,543,948
1892..	648,701	434,291	14,599,908	34,720	46,576,576	52,472,504	2,413,678	300,000	363,020	800,000†	8,710,878	1,000,000	2,454,449	180,399,217
1893..	783,300	457,045	14,719,929	50,000	42,942,532	53,810,214	1,857,432	322,745	416,605	842,933	8,891,323	1,211,550	2,243,401	180,859,510

* Census year. Nebraska, 1424 tons; Rhode Island, 14,000 tons, all anthracite of very refractory nature. The present average annual production of coal in Rhode Island may be taken at 5000 tons, and of Nebraska, all bituminous, at 1500 tons. † Estimated. ‡ Nearly all lignite. In 1891-3, Nebraska produced 1500 tons per annum. In 1889 North Carolina produced 192 tons; in 1890, 10,262; in 1891, 20,355; in 1892, 6417; in 1893, 17,000 tons.

PRODUCTION OF BITUMINOUS COAL, CONDITIONS OF MINING, AND COST PER TON OF 2000 LBS.

[Establishment numbers 1 to 146 are in the United States; numbers 147 to 151 are in the Dominion of Canada; numbers 152 to 160 are on the continent of Europe; numbers 161 to 173 are in Great Britain.]

Establishment No.	Width of Seam, inches.	Days Worked.	Tons per day per miner. Lump.	Tons per day per miner. Run of mine.	Size of Screen, inches.	Net average daily wages of Miner.*	Cost per Ton. Labor. Miners.	Cost per Ton. Labor. Others.	Cost per Ton. Labor. Total.	Cost per Ton. Officials and Clerks.	Cost per Ton. Supplies and Repairs.	Cost per Ton. Taxes.	Cost per Ton. Gross Total.	Cost per Ton. Value of Screenings.	Cost per Ton. Net Total.	Percentage of each Element of Cost. Labor.	Percentage. Officials.	Percentage. Supplies and Repairs.	Percentage. Taxes.
							cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.				
1	56	213	......	5.00	†	1.97	47.5	48	95.5	3.2	9.4	0.20	108.3	..	108.3	88.18	2.95	8.68	0.19
2	84	312	......	6.66	2½	2.63	45.0	13.1	58.1	2.2	8.2	1.9	70.4	....	70.4	82.53	3.12	11.65	2.70
3	a	296	......	4.40	†	......	f	g	82	5.6	14.5	0.3	102.9	....	102.9	80.18	5.44	14.09	0.29
4	b	301	......	3.00	2	......	f	g	78	2.1	3.7	0.1	84.7	....	84.7	93.03	2.48	4.37	0.12
5	54	e	......	4.80	†	.....	f	g	78	1.1	7.3	0.3	87.6	....	87.6	90.07	1.26	8.33	0.34
6	30	24	......	2.50	†	1.40	70.0	29.4	99.4	.....	4.6	....	104.0	....	104.0	95.58	.....	4.42	....
7	42	190	2.43	....	⅞	2.13	90.0	35.0	125	4.1	12.3	2.0	143.4	16.3	127.1	87.17	2.86	8.58	1.39
8	42	198	2.30	....	⅞	2.01	90.0	35.5	125.5	5.4	11.3	3.1	145.3	16.6	128.7	86.37	3.72	7.78	2.13
9	36	206	2.20	....	⅞	2.03	95.0	16.8	111.8	3.6	8.9	0.6	124.9	13.3	111.6	89.51	2.88	7.13	0.48
10	78	184	......	h	†	h	h	g	51.2	1.1	4.7	1.0	58.0	....	58.0	88.28	1.90	8.10	1.72
11	42	240	2.50	....	1	1.76	72.5	27.6	100.1	3.8	5.3	0.4	109.6	17.5	92.1	91.33	3.47	4.84	0.36
12	78	202	......	h	†	h	h	g	54.3	2.5	5.9	2.1	64.8	....	64.8	83.80	3.86	9.10	3.24
13	72	150	4.00	....	⅞	1.94	60.0	23.5	83.5	6.3	5.2	0.5	95.5	13.3	82.2	87.43	6.60	5.45	0.52
14	84	192	4.33	....	1¼	1.74	50.0	28.9	78.9	2.9	3.5	0.4	85.7	16.0	69.7	92.06	3.38	4.09	0.47
15	72	249	4.00	....	1	2.05	62.5	21.9	84.4	3.1	7.1	0.6	95.2	13.7	81.5	88.65	3.26	7.46	0.63
16	72	212	4.00	....	⅞	1.94	60.0	20.6	80.6	6.8	5.5	0.5	93.4	13.3	80.1	86.30	7.28	5.89	0.53
17	72	100	4.00	....	⅞	1.94	60.0	23.1	83.1	3.4	3.9	0.6	91.0	13.3	77.7	91.32	3.73	4.29	0.66
18	48	131	3.00	....	¾	2.02	70.0	29.8	99.8	6.0	8.5	0.5	114.8	16.6	98.2	86.93	5.23	7.41	0.43
19	38	22	2.30	....	⅞	1.96	87.5	27.5	115.0	1.2	12.5	0.8	129.5	13.2	116.3	88.80	0.93	9.65	0.62
20	36	20	2.21	....	⅞	1.88	87.5	20.2	107.7	0.6	12.8	0.6	121.7	13.2	108.5	88.50	0.49	10.52	0.49
21	42	18	2.43	....	⅞	1.94	82.5	28.2	110.7	3.8	10.5	1.8	126.8	16.6	110.2	87.30	3.00	8.28	1.42
22	36	15	2.23	....	⅞	1.89	87.5	24.0	111.5	3.8	10.2	0.6	126.1	12.0	114.1	88.42	3.01	8.09	0.48
23	42	20	2.32	....	⅞	1.85	82.5	26.9	109.4	4.4	10.6	2.4	126.8	16.2	110.6	86.28	3.47	8.36	1.89
24	57	17	2.67	....	⅞	1.80	72.5	33.0	105.5	1.3	9.9	0.6	117.3	16.6	100.7	89.94	1.11	8.44	0.51
25	60	151	3.00	....	1¼	2.00	72.5	21.2	93.7	2.5	5.3	0.2	101.7	15.9	85.8	92.13	2.46	5.21	0.20
26	60	177	......	h	†	h	h	g	59.0	8.1	5.3	0.7	73.1	....	73.1	80.71	11.08	7.25	0.96
27	54	200	8.0n	...	1¼	2.10	31.k	35.9	66.9	3.7	5.8	1.8	78.2	10.0	68.2	85.55	4.73	7.42	2.30
28	72	200	3.5o	....	1¼	......	l	g	82.2	3.0	10.1	1.8	97.1	16.0	81.1	84.66	3.09	10.40	1.85
29	78	155	3.00	....	1	1.81	67.5	26.3	93.8	6.7	6.6	1.0	108.1	13.8	94.3	86.77	6.20	6.11	0.92
30	66	191	3.3o	....	1⅓	......	m	g	85.0	3.0	5.5	0.5	94.0	16.0	78.0	90.43	3.19	5.85	0.53
31	72	116	10.0n	....	1¼	1.94	20.k	59.6	79.6	6.2	7.3	0.5	93.6	9.4	84.2	85.04	6.62	7.80	0.54
32	60	157	3.00	....	1⅓	2.07	75.0	18.1	93.1	6.8	7.0	0.4	107.3	15.9	91.4	86.77	6.34	6.52	0.37
33	48	87	3.33	....	1⅛	2.06	75.0	18.5	93.5	4.5	4.0	0.6	102.6	15.9	86.7	91.13	4.39	3.90	0.58
34	78	52	3.00	....	1	1.81	67.5	31.5	99.0	11.1	6.5	0.5	117.1	12.0	105.1	84.54	9.48	5.55	0.43
35	126	230	......	5.35	†	2.29	44.8	9.2	54.0	0.9	4.1	2.0	61.0	....	61.0	88.52	1.48	6.72	3.28
36	168	160	......	5.23	†	2.25	45.0	15.0	60.0	5.7	7.3	0.9	73.9	....	73.9	81.19	7.71	9.88	1.22
37	120	260	......	5.46	†	2.33	44.8	7.7	52.5	1.1	4.9	1.2	59.7	....	59.7	87.94	1.84	8.21	2.01
38	120	20	......	5.28	†	2.36	46.7	9.1	55.8	1.3	6.7	1.8	65.6	....	65.6	85.06	1.98	10.22	2.74
39	120	22	......	5.23	†	2.22	44.6	8.3	52.9	1.9	5.2	0.9	60.9	....	60.9	86.86	3.12	8.54	1.48
40	36	165	1.83	....	1¼	1.20	75.0	45.8	120.8	11.9	20.6	0.1	153.4	21.2	132.2	78.75	7.76	13.43	0.06
41	72	156	2.23	....	1⅓	1.45	82.5	23.8	106.3	15.6	9.7	0.4	132.0	34.4	97.6	80.53	11.82	7.35	0.30
42	46	190	2.75	....	1¼	1.66	65.0	11.8	76.8	4.0	42.1	0.2	123.1	31.8	91.3	62.39	3.25	34.40	0.16
43	108	140	3.83	....	1¼	2.28	65.0	10.4	75.4	1.0	3.2	0.2	79.8	5.5	74.3	94.49	1.25	4.01	0.25
44	48	144	3.08	....	1¼	1.74	65.0	13.0	78.0	9.9	4.4	....	92.3	11.7	80.6	84.50	10.73	4.77	....
45	66	149	2.42	....	1¼	1.43	65.0	83.8	148.8	3.7	6.3	0.7	159.5	32.1	127.4	93.29	2.32	3.95	0.44
46	c	150	6.3n	....	1¼	1.98	33.8k	45.3	79.1	4.1	8.4	0.1	91.7	13.0	78.7	86.26	4.47	9.16	0.11
47	d	150	2.50	....	1¼	1.74	79.0	10.0	89.0	4.7	6.9	0.8	101.4	10.6	90.8	87.77	4.64	6.80	0.79
48	51	153	2.47	....	1⅛	1.80	80.0	36.4	116.4	6.6	16.8	0.1	139.9	14.5	125.4	83.20	4.72	12.01	0.07
49	60	156	3.03	....	1½	1.82	65.0	37.6	102.6	6.1	5.6	0.8	115.1	23.7	91.4	89.14	5.30	4.87	0.69
50	36	156	2.00	....	1¼	1.12	65.0	43.1	108.1	0.6	7.5	0.1	116.3	15.5	100.8	92.95	0.52	6.44	0.09
51	72	162	3.38	....	1¼	2.00	65.0	20.1	85.1	2.2	7.3	0.1	94.7	6.7	88.0	89.86	2.32	7.71	0.11
52	48	164	h	...	1¼	......	h	g	93.5	8.9	30.8	0.5	133.7	6.8	126.9	69.93	6.66	23.04	0.37
53	48	166	2.55	....	1¼	2.00	85.0	30.6	115.6	8.4	8.9	0.1	133.0	23.2	109.8	86.92	6.32	6.69	0.07
54	54	174	2.78	....	1⅓	2.29	92.5	33.4	125.9	7.2	15.0	0.1	148.2	19.1	129.1	84.95	4.86	10.12	0.07
55	54	175	3.50	....	1¼	2.15	65.0	15.3	80.3	8.3	2.7	.	91.3	11.2	80.1	87.95	9.09	2.96	....
56	66	171	3.13	....	1¼	z[1]1.97	65.0	22.7	87.7	4.4	7.8	0.2	100.1	11.7	88.4	87.61	4.40	7.79	0.20
57	72	180	3.22	....	1¼	1.77	65.0	21.1	86.1	6.9	3.6	0.1	96.7	15.4	81.3	89.04	7.14	3.72	0.10
58	i	180	2.87	....	1⅓	z[1]2.04	80.0	30.0	110.0	6.9	4.0	0.1	121.0	9.2	111.8	90.91	5.70	3.31	0.08
59	j	180	2.42	....	1¼	1.70	86.0	20.0	106.0	15.0	8.0	0.2	129.2	26.6	102.6	82.04	11.61	6.19	0.16
60	48	182	2.00	....	1⅓	1.37	80.0	29.1	109.1	6.7	14.6	....	130.4	21.0	109.4	83.67	5.14	11.19	....
61	66	186	3.05	....	1¼	1.69	63.0	12.1	75.1	7.3	15.6	1.3	99.3	21.8	77.5	75.63	7.35	15.71	1.31
62	46	208	1.83	...	1½	1.41	81.0	50.9	131.9	18.2	15.3	1.0	166.4	35.2	131.2	79.27	10.94	9.19	0.60
63	48	212	3.66	....	1¼	2.18	65.0	33.9	98.9	2.5	9.7	0.4	111.5	15.4	96.1	88.70	2.24	8.70	0.36
64	72	218	3.16	....	1¼	1.89	65.0	11.5	76.5	7.6	7.7	0.6	92.4	14.3	78.1	82.79	8.23	8.33	0.65
65	56	226	2.33	....	1⅓	1.40	65.0	32.1	97.1	4.2	5.0	0.1	106.4	26.0	80.4	91.76	3.95	4.70	0.09
66	60	226	2.50	....	1¼	1.77	83.5	20.7	104.2	3.8	8.2	0.1	116.3	21.1	95.2	89.60	3.27	7.05	0.08
67	72	234	h	....	1¼	h	h	g	70.3	1.9	3.3	0.1	75.6	10.6	65.0	92.99	2.51	4.37	0.13
68	48	240	3.33	....	1½	2.03	65.0	43.9	108.9	2.4	25.6	0.2	137.1	31.7	105.4	79.43	1.75	18.67	0.15
69	66	250	2.83	...	1¼	1.72	65.0	31.9	96.9	3.6	9.4	0.1	110.0	24.0	86.0	88.09	3.27	8.55	0.09
70	57	251	2.08	....	1¼	z[1]1.24	65.0	22.3	87.3	2.5	6.6	0.4	97.8	41.5	56.3	89.26	3.58	6.75	0.41
71	48	253	2.66	....	1½	1.46	65.0	26.6	91.6	9.1	3.9	1.3	105.9	37.3	68.6	86.50	8.59	3.68	1.23
72	60	280	2.00	....	1¼	1.41	80.3	49.2	129.5	15.6	19.0	0.2	164.3	18.5	145.8	78.82	9.50	11.56	0.12
73	42	282	1.50	....	1¼	1.00	75.0	77.1	152.1	4.3	16.8	3.7	176.9	52.7	124.2	85.98	2.43	9.50	2.09
74	q	288	2.28	...	1¼	1.65	79.0	16.9	95.9	1.8	5.9	0.1	103.7	10.5	93.2	92.48	1.73	5.69	0.10
75	72	290	o 3.83	....	1¼	2.31	z	g	75.3	1.1	4.4	0.1	80.9	6.9	74.0	93.08	1.36	5.44	0.12

PRODUCTION OF BITUMINOUS COAL, CONDITIONS OF MINING, AND COST PER TON OF 2000 LBS.

[Establishments numbers 1 to 146 are in the United States; numbers 147 to 151 are in the Dominion of Canada; numbers 152 to 160 are on the continent of Europe; numbers 161 to 173 are in Great Britain.]

Establishment No.	Width of Seam, inches.	Days Worked.	Tons per day per miner. Lump.	Tons per day per miner. Run of mine.	Size of Screen, inches.	Net average daily wages of Miner.*	Cost per Ton. Labor. Miners.	Cost per Ton. Labor. Others	Cost per Ton. Labor. Total.	Cost per Ton. Officials and Clerks.	Cost per Ton. Supplies and Repairs.	Cost per Ton. Taxes.	Cost per Ton. Gross Total.	Cost per Ton. Value of Screenings.	Cost per Ton. Net Total.	Percentage of each Element of Cost. Labor.	Percentage of each Element of Cost. Officials.	Percentage of each Element of Cost. Supplies and Repairs.	Percentage of each Element of Cost. Taxes.
							cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.				
76	48	300	......	3.75	1¼	1.73	50.0	21.0	71.0	4.7	9.8	0.1	85.6	....	85.6	82.94	5.49	11.45	0.12
77	96	w	3.35	....	1¼	2.05	65.8	18.7	84.5	4.9	6.3	1.8	97.5	11.3	86.2	86.67	5.02	6.46	1.85
78	q	x	y 2.36	....	1⅓	1.36	65.0	44.6	109.6	6.9	17.6	0.4	134.5	19.3	115.2	84.48	5.13	13.09	0.30
79	r	294	2.45	..	1¼	1.51	67.5	21.3	88.8	3.0	6.1	2.4	100.3	12.3	88.0	88.53	2.99	6.09	2.39
80	42	114	3.21	....	1½	1.75	65.0	20.2	85.2	2.2	4.1	0.1	91.6	6.6	85.0	93.01	2.40	4.48	0.11
81	54	90	3.33	....	1½	2.52	79.0	30.2	109.2	1.0	17.4	1.6	129.2	10.8	118.4	84.52	0.77	13.47	1.24
82	48	100	3.33	....	1¼	2.52	79.0	29.0	108.0	0.8	14.0	1.7	124.5	11.0	113.5	86.74	0.64	11.25	1.37
83	54	101	3.50	....	1½	2.56	79.0	18.5	97.5	0.9	10.9	0.7	110.0	11.0	99.0	88.64	0.82	9.91	0.63
84	48	120	3.16	....	1½	2.34	79.0	28.0	107.0	3.2	7.2	0.4	117.8	8.7	109.1	90.83	2.72	6.11	0.34
85	48	161	3.00		1½	2.25	79.0	25.3	104.3	2.0	5.6	0.4	112.3	8.7	103.6	92.88	1.78	4.98	0.36
86	42	200	......	4.74	†	1.69	44.6	19.0	63.6	2.8	1.7	2.0	70.1	....	70.1	90.73	4.00	2.42	2.85
87	48	140	......	3.73	†	1.48	44.6	7.7	52.3	2.7	11.5	0.2	66.7	....	66.7	78.41	4.05	17.24	0.30
88	53	48	2.80	....	1½	2.09	79.0	24.5	103.5	6.6	4.4	0.6	115.1	8.7	106.4	89.92	5.73	3.83	0.52
89	60	170	3.00	...	1½	2.00	73.0	25.1	98.1	9.0	3.1	0.3	110.5	8.7	101.8	88.78	8.15	2.80	0.27
90	60	202	......	4.48	†	1.87	44.6	13.1	57.7	2.9	6.4	0.8	67.8	....	67.8	85.10	4.28	9.44	1.18
91	54	204	2.33	....	1½	1.62	73.3	19.4	92.7	6.4	8.3	0.4	107.8	11.9	95.9	86.00	5.94	7.69	0.37
92	72	225		3.33	¾	z^{1}1.97	60.0	18.6	78.6	1.1	8.6	0.3	88.6	....	88.6	88.71	1.24	9.71	0.34
93	54	230	2.00	....	u^{1}	1.48	79.0	9.3	88.3	6.2	8.9	0.7	104.1	12.0	92.1	84.82	5.96	8.55	0.67
94	60	230	......	3.73	†	1.44	44.6	15.6	60.2	2.2	5.5	0.7	68.6	....	68.6	87.75	3.21	8.02	1.02
95	48	233	......	3.54	†	f	f	g	66.8	1.2	3.7	0.6	72.3	....	72.3	92.39	1.66	5.12	0.83
96	52	236	3.00	....	1½	f	f	g	98.8	8.1	8.3	2.9	118.1	8.7	109.4	83.66	6.86	7.03	2.45
97	s	236	......	3.66	†	1.54	45.0	17.4	62.4	1.2	4.8	0.8	69.2	....	69.2	90.17	1.73	6.94	1.16
98	46	239	......	3.17	†	z^{1}1.35	44.6	19.6	64.2	0.5	6.4	0.6	71.7	....	71.7	89.54	0.70	8.92	0.84
99	42	250	......	3.36	†	z^{1}1.47	44.6	16.0	60.6	4.4	2.4	0.1	67.5	....	67.5	89.78	6.52	3.55	0.15
100	50	250	......	4.00	†	1.40	45.0	20.0	65.0	5.0	8.5	0.7	79.2	....	79.2	82.07	6.31	10.74	0.88
101	60	250	2.00	....	1½	1.28	73.5	16.8	90.3	4.0	8.4	0.5	103.2	17.3	85.9	87.50	3.88	8.14	0.48
102	50	250	2.50	....	1½	1.76	73.0	16.1	89.1	1.8	5.2	0.9	97.0	7.8	89.2	91.86	1.85	5.36	0.93
103	54	250	.....	4.24	†	1.68	44.6	17.8	62.4	0.2	1.2	....	63.8	....	63.8	97.81	0.31	1.88	....
104	t	252	......	3.73	†	1.54	44.6	17.0	61.6	1.2	4.1	0.5	67.4	....	67.4	91.39	1.78	6.09	0.74
105	u	256	.....	5.15	1½	2.16	44.6	8.5	53.1	1.0	3.1	0.6	57.8	....	57.8	91.87	1.73	5.36	1.04
106	60	256	......	3.96	1½	1.64	45.0	25.9	70.9	1.2	3.6	0.6	76.3	....	76.3	92.92	1.57	4.72	0.79
107	v	260	2.43		u^{1}	f	f	g	92.7	2.1	11.2	0.3	106.3	12.8	93.5	87.21	1.97	10.54	0.28
108	54	262	......	4.14	†	z^{1}1.80	44.6	8.0	52.6	0.4	4.9	0.6	58.5	....	58.5	89.91	0.68	8.38	1.03
109	66	270	......	3.33	†	z^{1}1.38	42.8	9.1	51.9	0.7	4.2	0.7	57.5	....	57.5	90.26	1.22	7.30	1.22
110	60	288	....	3.54	g	z^{1}1.48	43.1	18.6	61.7	0.4	5.3	0.1	67.5	....	67.5	91.41	0.59	7.85	0.15
111	50	300	......	4.00	†	1.40	45.0	23.0	68.0	4.6	8.5	0.8	81.9	....	81.9	83.03	5.62	10.37	0.98
112	54	300	......	4.24	†	1.79	44.6	13.2	57.8	0.5	1.0	....	59.3	....	59.3	97.47	0.84	1.69	....
113	48	300	......	2.98	†	1.22	45.0	16.2	61.2	0.4	1.4	....	63.0	....	63.0	97.14	0.64	2.22	...
114	48	300	......	4.85	†	2.02	44.6	9.1	53.7	0.4	1.5	....	55.6	....	55.6	96.58	0.72	2.70	...
115	54	300	......	4.48	†	1.91	44.6	19.7	64.3	1.3	1.0	....	66.6	....	66.6	96.55	1.95	1.50	....
116	72	70	3.16	....	v^{1}	z^{1}2.46	79.0	11.7	90.7	9.1	5.7	0.7	106.2	8.3	97.9	85.41	8.57	5.36	0.66
117	72	104	1.98	....	1½	1.46	79.0	16.7	95.7	2.7	5.4	0.7	104.5	6.2	98.3	91.58	2.58	5.17	0.67
118	72	111	3.00	....	1½	2.20	79.0	19.0	98.0	3.2	3.4	1.1	105.7	8.3	97.4	92.72	3.03	3.21	1.04
119	60	136	2.50	....	1½	1.75	73.0	17.0	90.0	7.8	3.1	0.5	101.4	12.5	88.9	88.76	7.69	3.06	0.49
120	s	136	2.16	....	u^{1}	w^{1}1.58	73.0	17.4	90.4	5.3	6.6	0.4	102.7	10.0	92.7	88.02	5.16	6.43	0.39
121	48	175	2.66	....	u^{1}	1.83	73.0	22.9	95.9	3.4	2.7	0.4	102.4	9.0	93.4	93.65	3.32	2.64	0.39
122	54	180	2.00	....	1¼	1.50	79.0	21.2	100.2	2.2	2.8	0.9	106.1	8.7	97.4	94.44	2.07	2.64	0.85
123	58	182	2.20	....	u^{1}	1.00	73.0	28.2	101.2	4.2	6.9	1.0	133.3	11.3	102.0	89.32	3.71	1.09	0.88
124	108	183	3.00	....	1⅛	1.49	53.0	24.5	77.5	2.4	4.0	0.3	84.2	10.3	73.9	92.04	2.85	4.75	0.36
125	54	199	2.50	...	1⅛	1.74	73.0	13.1	86.1	4.1	6.1	0.7	97.0	5.2	91.8	88.76	4.23	6.29	0.72
126	45	200	......	3.92	†	1.47	40.2	15.0	55.2	4.8	16.0	g	t^{1}76.0	....	t^{1} 76.0	72.63	6.32	21.05	....
127	60	210	2.66	...	1¼	1.77	73.0	13.2	86.2	3.5	5.1	0.4	95.2	10.7	84.5	90.55	3.68	5.35	0.42
128	54	222	2.33	..	1½	z^{1}1.79	79.0	13.9	92.9	0.8	3.7	0.3	97.7	8.3	89.4	95.09	0.82	3.78	0.31
129	48	225	2.66	....	u^{1}	1.83	73.0	14.7	87.7	4.0	3.3	0.2	95.2	9.3	85.9	92.12	4.20	3.47	0.21
130	48	230	1.86	....	¾	1.30	73.0	26.7	99.7	11.7	3.6	0.3	115.3	8.6	106.7	86.47	10.15	3.12	0.26
131	66	232	m^{1}	....	1⅛	2.53	70.0	21.6	91.6	3.8	5.0	1.2	101.6	8.7	92.9	90.16	3.74	4.92	1.18
132	48	244	1.96	....	1⅛	1.33	73.0	15.1	88.1	3.9	8.0	0.5	100.5	11.2	89.3	87.66	3.88	7.96	0.50
133	60	247	......	4.00	†	z^{1}1.70	45.0	12.2	57.2	5.7	5.0	1.1	69.0	....	69.0	82.90	8.26	7.25	1.59
134	a^{1}	203	g	g	u^{1}	......	p^{1}	g	78.4	4.3	11.1	0.5	94.3	13.1	81.2	83.14	4.56	11.77	0.53
135	48	250	2.11	....	1⅛	1.44	73.0	22.5	95.5	14.2	3.2	0.6	113.5	8.3	105.2	84.14	12.51	2.82	0.53
136	64	30	5.00	....	1½	2.55	53.0	27.9	80.9	3.0	20.4	....	104.3	21.4	82.9	77.56	2.88	19.56	....
137	48	102	......	4.48	†	1.87	44.6	16.7	61.3	1.5	1.7	....	64.5	....	64.5	95.04	2.33	2.63	....
138	56	50	1.88	....	u^{1}	1.26	73.0	18.2	91.2	8.7	4.8	0.6	105.3	8.7	96.6	86.61	8.26	4.56	0.57
139	a	200	2.50	....	u^{1}	......	f	g	81.7	2.1	5.6	0.1	89.5	10.0	79.5	91.28	2.35	6.26	0.11
140	30	226	......	3.00	†	2.02	70.0	65.0	135.0	3.7	8.7	0.4	147.8	....	147.8	91.34	2.50	5.89	0.27
141	144	310	......	6.71	2	z^{1}2.17	33.5	14.7	48.2	0.6	3.9	r^{1}	52.7	....	52.7	91.46	1.14	7.40	....
142	72	150	......	4.00	1⅜	1.82	50.0	13.2	63.2	4.2	6.5	0.2	74.1	....	74.1	85.29	5.67	8.77	0.27
143	66	201	......	4.67	1⅛	2.22	50.0	19.6	69.6	9.4	6.3	....	85.3	....	85.3	81.60	11.02	7.38	....
144	168	232	......	5.72	†	2.45	44.8	8.3	53.1	0.9	3.4	0.6	58.0	....	58.0	91.55	d1.55	5.87	1.03
145	66	234	......	3.55	†	1.60	50.0	23.8	73.8	2.3	8.0	1.0	85.1	....	85.1	86.72	2.70	9.40	1.18
146	60	276	......	3.00	†	1.44	50.0	17.8	67.8	3.5	14.6	0.3	86.2	....	86.2	78.65	4.06	16.94	0.35
147	g	214	......	4.08	¾	1.57	42.4	56.9	99.3	3.7	20.7	s^{1}7.2	s^{1}130.9	....	s^{1}130.9	75.86	2.83	15.81	5.50
148	g	255	......	5.50	¾	1.77	32.2	45.9	78.1	3.1	7.6	s^{1}6.2	s^{1} 95.0	....	s^{1} 95.0	82.21	3.26	8.00	6.53
149	g	260	......	5.14	¾	1.74	37.4	40.3	77.7	1.1	10.5	s^{1}5.8	s^{1} 95.1	....	s^{1} 95.1	81.70	1.16	11.04	6.10
150	g	263	......	5.60	¾	2.03	37.2	51.1	88.3	4.7	12.1	s^{1}6.8	s^{1}111.9	....	s^{1}111.9	78.91	4.20	10.81	6.80

PRODUCTION OF BITUMINOUS COAL, CONDITIONS OF MINING, AND COST PER TON OF 2000 LBS.

(Establishments numbers 1 to 146 are in the United States; numbers 147 to 151 are in the Dominion of Canada; numbers 152 to 160 are on the Continent of Europe; numbers 161 to 173 are in Great Britain.)

Establishment No.	Width of Seam, Inches.	Days Worked.	Tons per day per Miner.		Size of Screen, Inches.	Net Average Daily Wages of Miner.*	Cost per Ton.										Percentage of each Element of Cost.			
							Labor.													
			Lump.	Run of Mine.			Miners.	Others.	Total.	Officials and Clerks.	Supplies and Repairs.	Taxes.	Gross Total.	Value of Screenings.	Net Total.	Labor.	Officials.	Supplies and Repairs.	Taxes.
						$	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.				
151	g	290	....	3.73	¾	2.01	59.5	57.4	116.9	5.7	10.6	$s^1$6.1	$s^1$139.3	....	$s^1$139.3	83.92	4.09	7.61	4.38
152	30	301	...	5.54	x^1	......	q^1	g	62.2	2.6	12.8	$s^1$1.8	s^1 89.4	....	s^1 89.4	69.57	2.91	25.51	2.01
153	b^1	24	....	5.88	†	......	q^1	g	87.4	7.8	29.2	$s^1$1.4	$s^1$125.8	....	$s^1$125.8	69.47	6.20	23.22	1.11
154	b^1	24	....	3.85	†	......	q^1	g	104.6	8.3	37.3	$s^1$1.8	$s^1$152.0	...	$s^1$152.0	68.82	5.46	24.54	1.18
155	b^1	24	....	7.61	†	......	q^1	g	91.3	5 1	30.3	$s^1$1.8	$s^1$128.5	...	$s^1$128.5	71.05	3.97	23.58	1.40
156	124	75	...	3.28	x^1	1.00	31.5	66.6	98.1	2.5	23.7	$s^1$1.5	$s^1$125.8	...	$s^1$125.8	77.98	1.99	18.84	1.19
157	c^1	299	....	6.68	u^1	0.63	12.1	16.1	28.2	1.3	14.1	$s^1$3.4	s^1 47.0	..	s^1 47.0	60.00	2.77	30.00	7.23
158	d^1	299	....	7.23	y^1	0.77	13.1	18.6	31.7	1.7	9.1	$s^1$2.9	s^1 45.4	....	s^1 45.4	69.82	3.75	20.04	6.39
159	c^1	26	....	2.41	†	0.86	38.4	40.5	78.9	0.9	25.3	$s^1$5.9	$s^1$111.0	....	$s^1$111.0	71.08	0.81	22.80	5.31
160	f^1	75	....	2.98	†	2.06	70.2	9.0	79.2	1.2	21 0	$s^1$5.8	$s^1$107.2	....	$s^1$107.2	73.88	1.12	19.59	5.41
161	g^1	72	....	3.36	1	......	f	g	93.1	4.6	25.6	2.6	126 8	...	126.8	73.42	3.63	20.90	2.05
162	h^1	73	....	3.36	1	......	f	g	95.5	4.6	25 7	2.6	128.4	....	128.4	74.38	3.58	20.02	2.02
163	i^1	73	....	3.36	1	......	f	g	108.0	4.6	35.9	2.6	151.1	..	151.1	71.48	3.04	23.76	1.72
164	h^1	73	....	3.36	1	......	f	g	87.2	4.6	26.9	2.6	121.3	....	121.3	71.89	3.79	22.18	2.14
165	j^1	141	....	3.23	1¼	......	f	g	69.6	1.7	22.5	2.2	96.0	....	96.0	72.50	1.77	23.44	2.29
166	h^1	256	....	2.76	y^1	1.26	48.4	19.4	67.8	2.6	14.8	3.3	88.5	....	88.5	76.61	2.94	16.72	3.73
167	l^1	135	....	2.40	y^1	......	f	g	70.4	3.8	18.3	2.2	94.7	....	94.7	74.34	4.01	19.83	2.32
168	48	139	....	2.80	y^1	1.37	52.1	36.0	88.1	4.2	15.0	2.3	109.6	...	109.6	80.38	3.83	13.69	2.10
169	48	146	....	3.91	y^1	......	f	g	70.7	4.3	10.7	2.3	88.0	....	88.0	80.34	4 89	12.16	2.61
170	72	149	....	o^1	y^1	1.72	46.2	28.7	74.9	3.6	10 6	2.0	91.1	....	91.1	82.21	3.95	11.64	2.20
171	96	156	....	7.28	y^1	......	f	g	83.0	0.7	12.2	g	t^1 95.9	....	t^1 95.9	86.55	0.73	12.72	....
172	96	24	....	2.60	y^1	1.08	41.5	41.1	82.6	3.6	14.0	g	$t^1$100.2	....	$t^1$100.2	82.44	3.59	13.97	....
173	m^1	292	....	2.15	⅞	.....	f	g	86.8	3.2	16 8	2.2	109.0	..	109.0	79.63	2.94	15.41	2.02

* After deductions for cost of oil, smithing, powder, etc., have been made, when these are charged against the miner. No account is taken of allowances made of free coal, or of coal at reduced rates for personal use. (*a*) From 36 to 72. (*b*) From 34 to 48. (*c*) From 72 to 90. (*d*) From 48 to 72. (*e*) Vary in different mines from 250 to 308. (*f*) Miners' rates vary. (*g*) Not reported. (*h*) No hand miners employed. (*i*) From 30 to 66. (*j*) From 48 to 54. (*k*) Loaders in machine mine. (*l*) Only a few hand miners employed, and these at 67½ c. per ton. (*m*) Only a few hand miners employed, and these at 70c. per ton. (*n*) Loaders in machine mine. (*o*) Relates to hand mining only; mostly machine work. (*p*) From 24 to 36. (*q*) Two 42 each and one 78 (*r*) From 42 to 48. (*s*) From 54 to 60. (*t*) From 54 to 66. (*u*) From 54 to 96. (*v*) From 48 to 72. (*w*) One mine 18, one 193, one 196, one 207 days. (*x*) One mine 42, one 108, one 132 days. (*y*) One mine 13.4, one 14, and one 18 tons. (*z*) Only a few hand miners employed, and these at 65c. per ton; mostly machine work. (a^1) From 48 to 60. (b^1) From 20 to 79. (c^1) Four veins 79, 138, 157, and 236. (d^1) 236 and 315. (e^1) From 36 to 95. (f^1) Twenty-five veins from 28 to 87. (g^1) Four veins from 36 to 66. (h^1) Three veins from 33 to 66. (i^1) Three veins from 24 to 66. (j^1) From 36 to 78. (k^1) From 30 to 84. (l^1) One 33 and one 45. (m^1) From 30 to 90. (n^1) From 3.3 to 4.1 tons. (o^1) From 3.3 to 4.6 tons. (p^1) Only a few hand miners employed, and these at 74c. per ton; mostly machine work. (q^1) Miners not paid by ton. (r^1) Expenditures for supplies, repairs, and taxes are inseparably combined. (s^1) Including royalty to the State. (t^1) Not including taxes. (u^1) From 1¼ to ¾ inch. (v^1) From 1¼ to ⅝ inch. (w^1) Gross deductions not reported. (x^1) 0.47 to 1.77 inch. (y^1) Too varied to enumerate. (z^1) Slightly in excess of true amount, as returns for some of the deductions were not obtained. † None used.

Disregarding the additional theoretical cost, which is not an important part of the comparison, in the United States the average cost of run-of-mine coal was 72.8c., and of lump 92.5c.; in Canada run-of-mine cost $1.044; on the Continent of Europe 67.2c., and in Great Britain $1.004. In the United States the average labor cost of a ton of run-of-mine coal was 64.8c., or 89.28% of the total cost; in Canada it was 84.2c., or 80.70% of the total cost; on the Continent of Europe 45.6c., or 67.62% of the total cost; and in Great Britain 78c., or 77.52% of the total cost.

The labor cost of run-of-mine coal in the United States is thus, on the average, considerably higher than in Canada and Great Britain and 21.66% higher than on the Continent, looking at the matter without regard to output per miner per

week. When this is considered, however, it is seen that the average number of tons of run-of-mine coal per miner per week in 30 establishments in the United States was 23.84; in 5 establishments in Canada, 24.66; in 9 establishments on the Continent, 27.74; and in 13 establishments in Great Britain, 18.48.

The labor cost per week for mining these several amounts was, in the United States, $1544.83; in Canada, $2076.37; on the Continent, $1264.94; and in Great Britain, $1441.44. So that for every dollar of labor cost per week in the United States there is spent $1.34 in Canada, 82c. on the Continent, and 93c. in Great Britain. These calculations refer entirely to hand-mined coal as it comes from the miner, without being screened or otherwise treated. Hand-mined generally costs a good deal more than machine-mined coal, the difference being occasionally as much as 50%. The cheapest-mined bituminous coal is now mined by hand and loaded on the railroad cars—every expense, improvements, etc., included—in some parts of the United States for about 45c. per ton of 2000 lbs.

Machine-mining is steadily being extended in this country, and not only is compressed air being used more and more each year, but electricity as well is gaining ground. Some of the best coal-cutters are now driven by the current, and electrical underground haulage (and lighting) is recommending itself for rapidity, easy control, and cheapness.

In the following table appear the imports, exports, production, and consumption of coal in the United States since 1867. From this it will appear that in every year since 1872, with the exception of 1881, when the difference was very slight, we have exported more than we imported, and that our imports have not exceeded two per cent of the production.

UNITED STATES COAL IMPORTS, EXPORTS, PRODUCTION, AND CONSUMPTION, 1867 TO 1892.

(Tons of 2000 lbs.)

Years.	Imports. *b*			Exports. *b*			Production.	Total Supply.	Per Capita.	
	Anthracite.	Bituminous.	Total.	Anthracite.	Bituminous.	Total.			Production, Pounds.	Consumption, Pounds.
1867...	*a*	570,978	570,978	216,061	103,241	319,302	31,754.831	32,006,507	1,749	1,762
1868..	*a*	441,303	441,303	215,365	96,730	312,095	35,244,911	35,374,119	1,905	1,912
1869...	*a*	489,694	489,694	317,836	*a*	317,836	37,799,907	37,971,765	1,999	2,010
1870...	*a*	465,615	466.615	*c* 135,628	119,638	255,266	33,003,315	33,214,664	1,710	1,729
1871...	1,087	482,168	483,255	150,719	149.385	300,104	39,308,810	39,491,961	1,985	1,994
1872...	436	543,270	543,706	290,714	158,268	448,982	50.410.038	50,504,762	2,488	2,494
1873...	2,487	515,230	517,717	383,241	271,547	654,788	55,100,938	54,963,867	2,656	2,648
1874...	527	547,110	547.637	450,141	404,868	855,009	51,637,005	51,329.633	2,418	2,404
1875...	154	489,119	489,273	354,095	227,570	581,665	53,121,029	53,028,637	2,431	2,426
1876...	1,598	448,707	450,305	378,485	257,760	636,245	51,328,217	51,142,277	2,271	2,262
1877...	705	555,313	556,018	469,045	360,264	829.309	57.371,989	57.098.698	2,473	2,461
1878...	176	641,586	641,762	351,424	381,539	732,963	54,505,434	54,414,233	2,291	2,286
1879...	545	544,881	545,426	433,345	309,120	742,465	68,189,630	67,992,591	2.789	2,780
1880...	9	528,435	5[illegible],444	439,740	249,359	680,099	73,647,997	73,487,342	2.934	2,927
1881...	1,351	731,318	732,669	517,672	213,961	731,633	88,247,430	88.248,466	3.434	3,433
1882...	40	891,208	891.248	620,200	352,0[illegible]	972,238	98,202,748	98,121,758	3,734	3,731
1883...	567	723,434	724,001	624,750	51[illegible],617	1,143,367	108,082,118	106,214,750	4,010	3,941
1884..	1,621	918,697	920,318	726,925	723,816	1,450,741	110,395,208	109,863,164	4,006	3,988
1885...	5,567	887,586	893.153	724,368	604,001	1,328,369	112,609,811	112,174,595	3,992	3,978
1886...	8,553	964,209	972,762	747,211	610,154	1,357,365	114,660,292	114,275,689	4,050	4,039
1887...	4,392	952,931	957,323	924,543	791,127	1,715,670	130,975,305	130,216,958	4,447	4,421
1888...	17,312	1,246,149	1,263,461	1,095,886	963,717	2,059,603	145,470,206	144,725,750	4,840	4,816
1889...	29,528	1,148,431	1,177,959	960,548	1,047,369	2,007,917	138,116,702	137,257,217	4,498	4,470
1890...	19,316	939,168	958,484	889,361	1,434,914	2,324,275	156,073,611	154,688,504	4,992	4,948
1891...	16,676	1,525,972	1,542,648	967,181	1,807,202	2,774,383	169,543,948	168,312,213	5,306	5,268
1892...	*a*	1,142,910	1,142,910	851,639	1,645,686	2,497,325	171,769,355	170,414,940	5,280	5,234

(*a*) Not reported.
(*b*) Imports and exports from 1867 to 1884, inclusive, are by fiscal years ending June 30, from that on by calendar years.
(*c*) Includes bituminous.

An attempt has been made in the following table to present the coal production of the principal countries of the world since 1870 in metric tons. It is thought to be sufficiently accurate for all ordinary purposes, and is given here with the hope that it will be as useful to the reader as it has been difficult of compilation to the writer.

COAL PRODUCTION OF THE WORLD.

(In metric tons of 2204 lbs.)

Year.	Gr. Britain.	Un. States.	France.	Germany.	Aus.-Hung.	Belgium.	Spain.	Russia.	All Other Countries.	Total.
1864	94,308,986	22,860,000	11,242,634	26,167,100	4,662,438	11,158,336	425,000	292,000	2,653,506	173,770,000
1865	99.759,613	24,790.400	11,840,000	28,327,800	2,028,089	11,840,603	450,000	331,000	2,712,495	182,080,000
1866	103,296,618	29,317,613	12,000,000	28,624,600	4,893,931	12,774,662	475,000	373,000	3,020.576	194,776.000
1867	106,213,603	28,815,636	11,856,945	30,982,500	6,098,804	12,755,822	500,000	412,000	3,114,690	200,730,000
1868	104,831,996	31,982,678	12,053,047	33,274,400	7,021,756	12,298,589	537,522	451,098	3,174,914	205,626,000
1869	109,188,664	34,301,186	12,580,820	34,379,600	7,663,043	12,942,094	560,000	550,000	3,483.593	215,649,000
1870	112,241,531	29,948,562	13,300,000	34,880,600	8,355,945	13,697,110	661,932	696,209	4,041,111	217,823,000
1871	119,275,832	35,670,426	12,759,400	38,391,300	8,437,401	13,733,176	500,000	829,722	4,097,743	233,695,000
1872	125,521,862	45,744,135	15,204,170	43,059,300	8,825,896	15,658,940	580,000	1,117,045	5,550,652	261,262,000
1873	130.789,643	50,000,851	17.479,341	47,131,800	10,104,769	15,713,293	580,000	1,392,880	6,076.423	279,269,000
1874	128,665,356	46,857.536	16,907,913	46,286,300	12.631,364	14,794,886	560,000	1,345,558	6,276,087	274,325,000
1875	135,491,837	48,204,201	16,956,840	48,532,400	13,062,738	15,011,331	610,000	1,171,736	6,258,917	285 300,000
1876	136,323,939	46,577,329	17,101,448	49,154.700	13,000,000	14,329,578	600,000	1,260,000	6,477.006	284,824.000
1877	136,379,640	52,161,696	16,804,529	48,454,700	13,500,000	13,938,523	650,000	1,390,000	7,670,912	290,850,000
1878	134,786,031	49,460.466	16,960,916	50,519,899	13.900,000	14,899,175	700,000	2,483,575	8,335,938	292,046,000
1879	135,912,531	61,878,067	17.110,979	53,470.716	14,500,000	15,447,292	770,000	2,909,931	8,792,484	310,792.000
1880	149,378,744	66,831,213	19,361,564	59,118,035	14,800,000	16,886,698	847,128	3,266,844	9,079,774	339,370,000
1881	156,711,911	80.079,338	19,775.983	61,540,485	15.304,813	16,873,951	1,271,410	3,437,840	9,839.269	364,825,000
1882	159,065,550	89,113,201	20,603,704	65,378.211	15,555,292	17,590,989	1,196,255	3,803,508	10,995,290	383,302,000
1883	166,421,545	98,078,147	21,333,884	70,442,648	17,047,961	18,177,754	1,044,480	4,366,682	11,663.699	408,577,000
1884	163,393,136	100,177,140	20.023,514	72.113,820	18,000,000	18,051.499	977,350	3,950,000	12,318,341	409.005,000
1885	161,963,736	102,186,761	19,510,530	73,675,515	20,435,463	17,437,603	945,904	4,273,476	12,389,072	412,818,000
1886	160,100.752	104,047,452	19,909,894	73,682,584	20,779,441	17,285,543	921,142	4,507,516	12,973.676	414,208,000
1887	164,777,514	118.852,364	21,287,589	76,232,618	23,125,000	18,378,624	1,038,305	4,464,174	14,007,812	442,164.000
1888	172,721,042	132,005,632	22,602,894	81,960,083	24,000,000	19,218,481	1,036,566	5,106.345	15,324,957	473,976.000
1889	179,816,998	125.287,388	24,303,509	84,973,230	25,326,417	19.869.980	1,014,720	6,118,560	16,062.198	482,773,000
1890	184,594,850	141,627,596	26,083,118	89,290,834	26,100,000	20,365,960	1,179.779	7,000,000	16,887,863	513,130,000
1891	188,519,767	153,851,132	26,199,745	94,252,278	27,000,000	19,865,345	1,286,000	7,000,000	17,126,733	535.101.000

COKE.

Reliable statistics of the manufacture of coke prior to 1880 are not available. The industry had indeed gained a foothold as early as 1850; for at that time, according to the census returns, there were in the United States 4 establishments, employing 14 men, having a capital of $3700, paying $3444 in wages, using materials—including coal—to the value of $6038, and producing coke to the value of $15,250.

The number of establishments, so far as can now be ascertained, from 1850 to and including 1891, is given in the following table:

NUMBER OF COKE ESTABLISHMENTS IN THE UNITED STATES, 1850–91.

Year, Census.	No.	Year, Calendar.	No.	Year, Calendar.	No.	Year, Calendar.	No.
1850	4	1880	186	1884	250	1888	261
1860	21	1881	197	1885	233	1889	252
1870	25	1882	215	1886	222	1890	253
1880	149	1883	231	1887	270	1891	248

For at least ten years prior to 1850 the use of coke in blast-furnaces had been successfully undertaken, as will appear from the article on "Iron and Steel," but it did not then secure a firm foothold.

Overman, in 1849, in his treatise, "The Manufacture of Iron," does not give much space to coke furnaces, saying in explanation: "As there is but little prospect of an addition to the number of coke furnaces which now exist, we shall devote but a limited space to this subject." And yet in 30 years after this curt dismissal of coke, the United States made 3,338,300 tons of coke, had 213 coke and bituminous coal furnaces out of a total of 701, and made 1,741,254 tons of coke and bituminous pig-iron out of a total of 3,835,190 tons.

The manufacture of coke, however, when once it had begun to grow, proceeded with great rapidity. In 1854 there was produced of coke and bituminous pig-iron 48,647 tons, and this amount had increased only to 187,611 tons in 1864. In 1865 it is not likely that the production of coke amounted to 100,000 tons per annum; but in 1874 the production of coke and bituminous pig-iron had increased to 813,137 tons, which would imply that the production of coke in that year was not less than 1,000,000 tons. It is therefore probable that within the ten years ending with 1875 the production of coke rose from 100,000 to more than 1,000,000 tons—an increase unprecedented in the annals of the coal and iron trade in this country. And it is further probable that this increase was almost wholly confined to the State of Pennsylvania; for in 1880, when the production of coke in the entire country was 3,338,300 tons, that of Pennsylvania was 2,821,384 tons, or 84.74% of the total.

Prior to 1880 it is probable that in no year did the production in Pennsylvania fall below 85% of the total, and in some years perhaps not below 90%.

Since 1880 the production of coke in Pennsylvania has been slowly but steadily diminishing, as compared with the rest of the country, although this State still produces more than 60% of the coke made in the United States. In 1880, as already observed, Pennsylvania produced 84.74% of the total, but in 1891 the output was 67.11% of the total. Ever since the first manufacture of coke in this country Pennsylvania has easily led all the States; but changes now in progress seem to indicate that within a few years she will lose this pre-eminence in tonnage, although the excellence of product will probably distinguish her for many years to come. Alabama has shown the greatest increase of production since 1880, as in that year her output was 60,781 tons, or 1.82% of the total, and in 1891 it was 1,282,496 tons, or 12.39% of the total. Pennsylvania and Alabama produce at this time more than three fourths of all the coke made in the country, their combined tonnage being about 8,250,000.

The following table, which has been obtained from the reports of Mr. Joseph D. Weeks to the United States Geological Survey, gives the statistics, by States, of the manufacture of coke from 1880 to and including 1891. It includes the number of establishments, the ovens built and building, the coal used, the coke produced, the percentage yield of coke, and its total and per ton value.

UNITED STATES COKE STATISTICS, BY STATES, FROM 1880 TO 1891. 1 TON = 2000 LBS.

	Establishments.	Ovens.		Coal Used, Tons.	Coke Produced, Tons.	Yield of Coke, %	Value of Coke.	
		Built.	Building.				Total.	Per Ton.
Alabama:								
1880	4	316	100	106,283	60,781	57	$183,063	$3.01
1881	4	416	120	184,881	109,033	59	326,819	3.00
1882	5	536	....	261,839	152,940	58	425,940	2.79
1883	6	767	122	359,699	217,531	60	598,473	2.75
1884	8	976	242	413,184	244,009	60	609,185	2.50
1885	11	1,075	16	507,934	301,180	59	755,645	2.50
1886	14	1,301	1,012	635,120	375,054	59	993,302	2.65
1887	15	1,555	1,362	550,047	325,020	59	775,090	2.39
1888	18	2,475	406	848,608	508,511	60	1,189,579	2.34
1889	19	3,944	427	1,746,277	1,030,510	59	2,372,417	2.30
1890	20	4,805	371	1,809,964	1,072,942	59	2,589,447	2.41
1891	21	5,068	50	2,144,277	1,282,496	60	2,986,242	2.33
Colorado:								
1880	1	200	50	51,891	25,568	49	145,226	5.68
1881	2	267	....	97,508	48,587	50	267,156	5.29
1882	5	344	....	180,549	102,105	57	476,665	4.67
1883	7	352	....	224,089	133,997	60	584,578	4.36
1884	8	409	24	181,968	115,719	64	409,930	3.45
1885	7	434	....	208,069	131,960	63	512,162	3.88
1886	7	483	....	228,060	142,797	62.6	569,120	3.99
1887	7	532	....	267,487	170,698	64	682,778	4.00
1888	7	602	100	274,212	179,682	65.6	716,305	4.00
1889	9	834	50	299,731	187,638	63	643,479	3.43
1890	8	916	30	407,023	245,756	60	959,246	3.90
1891	7	948	21	452,749	277,074	61	896,984	3.24
Georgia:								
1880	1	140	40	63,402	38,041	60	81,789	2.15
1881	1	180	40	68,960	41,376	60	88,753	2.15
1882	1	220	44	77,670	46,602	60	100,194	2.15
1883	1	264	36	111,687	67,012	60	147,166	2.20
1884	1	300	....	132,113	79,268	60	169,192	2.13
1885	2	300	....	117,781	70,669	60	144,198	2.04
1886	2	300	....	136,133	82,680	60	179,031	2.17
1887	2	300	....	158,482	79,241	50	174,410	2.20
1888	1	290	....	140,000	83,721	60	177,907	2.12
1889	1	300	....	157,878	94,727	60	149,059	1.57
1890	1	300	....	170,388	102,233	60	150,995	1.48
1891	1	300	....	164,875	103,057	62.5	231,878	2.25
Illinois:								
1880	6	176	....	31,240	12,700	41	41,950	3.30
1881	6	176	....	35,240	14,800	42	45,850	3.10
1882	7	304	....	25,270	11,400	45	29,050	2.55
1883	7	316	....	31,170	13,400	43	28,200	2.10
1884	9	325	....	30,168	13,095	43	25,639	1.96
1885	9	320	....	21,487	10,350	48	27,798	2.68
1886	9	335	....	17,806	8,103	46	21,487	2.65
1887	8	278	...	16,596	9,198	55.5	19,594	2.13
1888	8	221	....	13,020	7,410	56.9	21,038	2.84
1889	4	149	....	19,250	11,583	60	29,764	2.57
1890	4	148	....	9,000	5,000	55	11,250	2.25
1891	1	25	....	10,000	5,200	52	11,700	2.25

	Establishments.	Ovens.		Coal Used, Tons.	Coke Produced, Tons.	Yield of Coke, %	Value of Coke.	
		Built.	Building.				Total.	Per Ton.
Indiana:								
1886	4	100	18	13,030	6,124	47	$17,953	$2.93
1887	4	119	....	35,600	17,658	50	51,141	2.81
1888	3	103	....	26,547	11,956	45	31,993	2.68
1889	4	111	....	16,428	8,301	51	25,922	3.12
1890	4	101	....	11,753	6,013	51	19,706	3.27
1891	2	84	....	8,688	3,798	44	7,596	2.00
Indian Ter.:								
1880	1	20	....	2,494	1,546	62	4,638	3.00
1881	1	20	...	2,852	1,768	62	5,304	3.00
1882	1	20	....	3,266	2,025	62	6,075	3.00
1883	1	20	....	4,150	2,573	62	7,719	3.00
1884	1	20	....	3,084	1,912	62	5,736	3.00
1885	1	40	....	5,781	3,584	62	12,902	3.60
1886	1	40	....	10,242	6,351	62	22,229	3.30
1887	1	80	....	20,121	10,060	50	33,435	3.33
1888	1	80	....	13,126	7,502	57	21,755	2.90
1889	1	78	....	13,277	6,639	50	17,957	2.70
1890	1	78	....	13,278	6,639	50	21,577	3.25
1891	1	80	....	20,551	9,464	46	30,483	3.22
Kansas:								
1880	2	6	...	4,800	3,070	64	6,000	1.95
1881	3	15	....	8,800	5,670	64.4	10,200	1.80
1882	3	20	....	9,200	6,080	65	11,460	1.70
1883	4	23	....	13,400	8,430	62.9	16,560	1.96
1884	4	23	....	11,500	7,190	62.5	14,580	2.02
1885	4	23	....	15,000	8,050	53.6	13,255	1.65
1886	4	36	....	23,062	12,493	54.2	19,204	1.54
1887	4	39	....	27,604	14,950	54	28,575	1.91
1888	6	58	....	24,934	14,831	59	29,073	1.96
1889	6	68	....	21,600	13,910	64	26,593	1.91
1890	7	68	....	21,809	12,311	56	29,116	2.36
1891	6	72	....	27,181	14,174	52	33,296	2.34
Kentucky:								
1880	5	45	....	7,206	4,250	60	12,250	2.88
1881	5	45	...	7,406	4,370	60	12,630	2.89
1882	5	45	....	6,906	4,070	59	11,530	2.83
1883	5	45	....	8,437	5,025	60	14,425	2.87
1884	5	45	....	3,451	2,223	64	8,760	3.94
1885	5	33	....	5,075	2,704	53	8,489	3.14
1886	6	76	2	9,055	4,528	50	10,082	2.23
1887	6	98	....	29,129	14,565	50	31,730	2.18
1888	10	132	2	42,642	23,150	54	47,244	2.04
1889	9	166	100	25,192	13,021	52	29,769	2.28
1890	9	175	303	24,372	12,343	51	22,191	1.80
1891	7	115	24	64,390	33,777	52	68,281	2.02
Missouri:								
1887	1	4	....	5,400	2,970	55	10,395	3.50
1888	1	4	....	5,000	2,600	52	9,100	3.50
1889	3	9	....	8,485	5,275	62	5,800	1.10
1890	3	10	....	9,491	6,136	65	9,240	1.51
1891	3	10	....	10,377	6,872	66	10,000	1.45

UNITED STATES COKE STATISTICS, BY STATES, FROM 1880 TO 1891. 1 TON = 2000 LBS.—*Continued.*

	Establishments.	Ovens.		Coal Used, Tons.	Coke Produced, Tons.	Yield of Coke, %	Value of Coke.	
		Built.	Building.				Total.	Per Ton.
Montana:								
1883	1	2	.....	....	....	.....	....	.....
1884	3	5	12	165	75	46	900	12.00
1885	2	2	....	300	175	58.5	2,063	11.72
1886	4	16	....	....	....	.....	....	.....
1887	2	27	....	10,800	7,200	66.6	72,000	10.00
1888	1	40	....	20,000	12,000	60	96,000	8.00
1889	2	90	50	30,576	14,043	46	122,023	8.69
1890	2	140	....	32,148	14,427	45	125,655	8.71
1891	2	140	....	61,067	29,009	47	258,523	8.91
New Mexico:								
1882	2	....	12	1,500	1,000	66.6	6,000	6.00
1883	2	12	28	6,941	3,905	57.3	21,478	5 50
1884	2	70	....	29,990	18,282	57.3	91,410	5.00
1885	2	70	....	31,889	17,940	56.3	89,700	5.00
1886	2	70	....	18,194	10,236	56	51,180	5.00
1887	1	70	....	22,549	13,710	61	82,260	6.00
1888	1	70	....	14,628	8,540	58	51,240	6.00
1889	2	70	....	7,162	3,460	48	18,408	5.32
1890	2	70	....	3,980	2,050	51.5	10,025	4.89
1891	1	....	....	4,000	2,300	57.5	10,925	4.75
Ohio:								
1880	15	616	25	172,453	100,596	58	255,905	2.54
1881	15	641	....	201,045	119,469	59	297,728	2.49
1882	16	647	....	181,577	103,722	57	266,113	2.57
1883	18	682	....	152,502	87,834	58	225,660	2.57
1884	19	732	....	108,164	62,709	58	156,294	2.49
1885	13	642	....	68,796	39,416	57	109,723	2.78
1886	15	560	....	59,332	34,932	59	94,042	2.69
1887	15	585	223	164,974	93,004	56	245,981	2.65
1888	15	547	12	124,201	67,194	54	166,330	2.48
1889	13	462	....	132,828	75,124	56	188,222	2.50
1890	13	443	1	126,921	74,633	59	218,090	2.92
1891	9	421	....	69,320	38,718	56	76,901	1.99
Pennsylvania:								
1880	124	9,501	836	4,347,558	2,821,384	65	5,255,042	1.86
1881	132	10,881	761	5,393,505	3,437,708	64	5,898,579	1.70
1882	137	12,424	642	6,149,179	3,945,034	64	6,133,698	1.55
1883	140	13,610	211	6,823,275	4,438,464	65	5,410,387	1.22
1884	145	14,285	232	6,204,604	3,822,128	62	4,783,230	1.25
1885	133	14,553	317	6,178,500	3,991,805	64.6	4,981,656	1.25
1886	108	16,314	2,558	8,290,849	5,406,597	65.2	7,664,023	1.42
1887	151	18,294	802	8,938,438	5,832,849	65.3	10,746,352	1.84
1888	120	20,381	1,565	9,673,097	6,545,779	68	8,230,759	1.26
1889	109	22,143	567	11,581,292	7,659,055	66	10,743,492	1 40
1890	106	23,430	74	13,046,143	8,560,245	65	16,333,674	1.91
1891	109	25,324	11	10,588 544	6,954,846	66	12,679,826	1.82
Tennessee:								
1880	6	656	68	217,656	130,609	60	316,607	2.42
1881	6	724	84	241,644	143,853	60	342,585	2.38
Tennessee:								
1882	8	861	14	313,537	187,695	60	472,505	2.52
1883	a11	992	10	330,961	203,691	62	459,126	2.25
1884	13	1,105	175	348,295	219,723	63	428,870	1.95
1885	12	1,387	36	412,538	218,842	53	398,459	1.82
1886	12	1,485	126	621,669	368,139	59	687,865	1.87
1887	11	1,560	165	655,857	396,979	61	870,900	2.19
1888	11	1,634	84	630,099	385,693	61	490,491	1.27
1889	12	1,639	40	626,016	359,710	57	731,496	2.03
1890	11	1,664	292	600,387	348,728	58	684,116	1.96
1891	11	1,995	....	623,177	364,318	58	701,808	1.92
Virginia:								
1883	1	200	....	39,000	25,340	65	44,345	1.75
1884	1	200	....	99,000	63,600	64.3	111,300	1.75
1885	1	200	....	81,899	40,139	60	85,993	1.75
1886	2	350	100	200,018	122,352	61.2	305,880	2.50
1887	2	350	300	235,841	166,947	70.8	417,368	2.50
1888	2	550	....	230,529	140,199	64.7	260,000	1.74
1889	2	550	250	238,793	146,528	61	325,861	2.22
1890	2	550	250	251,683	165,847	66	278,724	1.68
1891	2	550	250	285,113	167,516	58.7	265,107	1.58
Washington:								
1884	1	....	....	700	400	57.5	1,900	4.75
1885	1	2	....	544	311	57	1,477	4.75
1886	1	11	21	1,400	825	58.9	4,125	5.00
1887	1	30	....	22,500	14,625	65	102,375	7.00
1888	3	30	100	....	....	.....	....	.....
1889	1	30	....	6,983	3,841	55	30,728	8.00
1890	2	30	80	9,120	5,837	64	46,696	8.00
1891	2	80	....	10,000	6,000	60	42,000	7.00
W. Virginia:								
1880	18	631	40	230,758	138,755	60	318,797	2.30
1881	19	689	....	304,823	187,126	61	429,571	2.30
1882	22	878	....	366,653	230,398	63	520,437	2.26
1883	24	962	9	411,159	257,519	63	563,490	2.19
1884	27	1,005	127	385,588	223,472	62	425,952	1.91
1885	27	978	63	415,533	260,571	63	485,588	1.86
1886	29	1,100	317	425,002	264,158	62	513,843	1.94
1887	39	2,080	742	698,327	442,031	63.3	976,732	2.21
1888	51	2,764	318	854,531	525,927	61.5	896,797	1.70
1889	53	3,438	631	1,001,372	607,880	60	1,074,177	1.76
1890	55	4,060	334	1,395,266	833,377	59	1,524,746	1.82
1891	55	4,621	555	1,716,976	1,009,051	52	1,845,043	1.83
Wisconsin:								
1888	1	50	....	1,000	500	50	1,500	3.00
1889	1	50	....	25,616	16,016	62.5	92,092	5.75
1890	1	70	....	38,425	24,976	65	143,612	5.75
1891	1	120	....	52,904	34,387	65	192,804	5.61
Wyoming:								
1891	1	24	....	4,470	2,682	60	8,046	3.00

The table which follows gives the production and imports of coke from 1880 to and including 1891. It has been prepared from the foregoing table, and from the returns of the United States Treasury Department. The exports of coke are inconsiderable.

UNITED STATES COKE STATISTICS: PRODUCTION AND IMPORTS (THE LATTER BY FISCAL YEARS) FROM 1880 TO 1891.

(1 ton = 2000 lbs.)

Year.	Establishments	Ovens.		Coal Used.	Coke Produced.	Yield of Coke.	Value of Coke.		Imports.	
		Built.	Building.				Total.	Per Ton	Tons.	Value.
				Tons.	Tons.	%	$	$		$
1880 .	186	12,372	1,159	5,237,741	3,338,300	63	6,631,267	1.99	5,047	$18,406
1881..	197	14,119	1,005	6,546,662	4,113,760	63	7,725,175	1.88	15,210	64,987
1882..	215	16,356	712	7,577,648	4,793,321	63	8,462,167	1.77	14,924	53,244
1883..	231	18,304	407	8,516,670	5,464,721	64	8,121,607	1.49	20,634	113,114
1884..	250	19,557	812	7,951,974	4,873,805	61	7,242,878	1.49	14,483	36,278
1885..	233	20,116	432	8,071,126	5,106,696	63	7,629,118	1.49	20,876	64,814
1886..	222	22,597	4,154	10,688,972	6,845,369	64	11,153,366	1.63	28,124	84,801
1887..	270	26,001	3,584	11,859,752	7,611,705	64.2	15,321,116	2.01	35,320	100,312
1888..	261	30,059	2,587	12,945,350	8,540,030	66	12,445,963	1.46	35,201	107,914
1889..	252	34,165	2,115	15,960,973	10,258,022	64	16,630,301	1.62	28,608	88,008
1890..	253	37,158	1,547	18,005,209	11,508,021	63	23,215,302	2.00	20,808	101,757
1891..	243	40,245	911	16,344,540	10,352,688	63	20,393,216	1.97	50,753	223,184

NOTE.—The total imports, as specified, from 1872 to and including 1879, were 31,130 tons, valued at $99,096. The value of the coke imported during the three years 1869, 1870, and 1871 was $27,969.

Practically all of the coke in the United States is made in bee-hive ovens, the attempts to introduce other systems of coking not having been successful commercially. As a rule the gases are not consumed; some establishments, however, utilize them for heating purposes. Tar and ammoniacal liquors are not saved, so that the 40% or 50% of volatile matter passes off into the air and is wasted. If we allow only 40% waste, an amount well within the mark, the 10,352,688 tons of coke made in 1891 represent 17,185,462 tons of coal, of which 6,874,184 tons were lost by being dissipated into the air as unconsumed smoke and gases. During the twelve years ending with 1891 the coke production of the United States was 82,806,438 tons, representing, on the same basis as before, 137,458,687 tons of coal, of which 54,983,474 tons were lost by the wasteful methods of coking in the bee-hive oven. Taking the average value of the coal per ton at $1,—also well within the mark,—we have thus, for the average annual loss in these twelve years, $4,581,957. But it is claimed that bee-hive coke is so much better for blast-furnace use than coke from recuperative ovens that we can afford to throw away 40% of the coal, or whatever else may be the difference between the two systems. This claim was substantiated, in a measure, by Sir I. Lowthian Bell, who experimented with several thousand tons of bee-hive and Simon-Carvés coke made in a recuperative oven, and found that the bee-hive coke was about 10% better than the Simon-Carvés. Sir Bernard Samuelson, however, in repeating the experiment, did not altogether confirm this result, so that we may hold the question as still undecided so far as concerns these experiments. But the experience in France, covering a number of years, is clearly in favor of the recuperative oven; and certainly the loss of 10% in reducing power, as reported by Bell, is not to be taken as condemnatory of a system that is highly prized elsewhere. The manufacture of coke has not shown the same scientific and economic progress as the mining of coal and the production of pig-iron and steel. We have advanced in output until we are now making close to 11,000,000 tons per annum, but we have shown little or no disposition to lessen the enormous waste of fuel that is connected with the open-top bee-hive oven. In another direction, also, we have not made satisfactory

progress, viz., in the mechanical and chemical betterment of the coal before it is charged into the oven, whether by simple crushing or by crushing and washing. It is impossible to say what proportion of the total amount of coke produced is made of crushed coal, or what proportion of crushed and washed coal; but it is not likely that 10% of the coal used is improved in either way.

The great deposits of high-grade coking coal in Western Pennsylvania, West Virginia, and Virginia may defer the consideration of this question to a later day in so far as concerns the coke made in some of these districts. But the more southerly States, and especially the Central and Western States, cannot long postpone the question if they desire to secure for themselves the best coke to be had from their own coal.

The following table, prepared from the report of Mr. Wright, already referred to, gives the cost of making coke in 30 establishments in the United States, 10 on the Continent of Europe, and 5 in Great Britain:

MANUFACTURE OF COKE: ELEMENTS OF COST IN 1 TON OF 2000 LBS.

(Establishments numbers 1 to 30 are in the United States; numbers 31 to 40 are on the Continent of Europe; and numbers 41 to 45 are in Great Britain.)

	No. Days Covered by Report.	Coke Produced.	Coal to 1 Ton Coke.	Cost per Ton Coke.						Percentages of Cost.				
				Coal.	Labor	Office.	Supplies.	Taxes.	Total.	Coal.	Labor.	Office.	Supplies.	Taxes
		Tons.	Lbs.	$	Cts.	Cts.	Cts.	Cts.	$					
1	313	75,949	3,701	2.028	34.8	1.3	2.6	0.1	2.416	83.94	14.40	0.54	1.08	0.04
2	313	65,520	3,446	1.911	30.2	5.5	0.9	*e*	*f* 2.277	83.93	13.26	2.42	0.39	....
3	304	64,411	3,563	1.887	37.3	7.9	6.2	0.2	2.403	78.53	15.52	3.29	2.58	0 08
4	300	45,059	3,277	2.089	39.4	3 3	3.4	0.7	2.557	81.70	15.41	1.29	1.33	0.27
5	352	267,514	3,400	1.700	36.0	3 6	4.0	0.7	2.143	79.33	16.80	1.68	1.86	0.33
6	362	111,039	3,110	1.864	28.6	*b*	13.1	0.2	2.283	81.64	12.53	... ...	5.74	0.09
7	353	137,693	3,333	1.461	43.9	*b*	6.9	0.2	1.971	74.13	22.27	....	3.50	0.10
8	24	2,600	3,231	1.770	76.9	....	3.8	*e*	*f* 2.577	68.68	29.84	......	1.40	....
9	234	4,000	2,800	0.620	56.0	2.5	2.5	1.0	1.240	50.00	45.16	2.02	2.02	0.80
10	310	34,055	3,595	1.213	32.8	2.6	1.3	0.4	1.584	76.58	20.71	1.64	0.82	0.25
11	165	27,282	2,929	0.727	28.2	1.6	3.0	0.3	1.058	68.72	26.65	1.51	2.84	0.28
12	172	21,980	3,124	0.767	27.9	1.4	3.2	0.4	1.096	69.98	25.46	1.28	2.92	0.36
13	226	169,920	2,823	0.717	30.8	0.7	7.5	0.1	1.108	64.71	27.80	0.63	6.77	0.09
14	229	43,744	2,913	0.830	31.1	0.9	5.4	....	1.204	68.94	25.83	0.75	4.48	....
15	149	26,818	2,519	0.718	37.0	2.8	1.3	0.3	1.132	63.43	32.69	2.47	1.15	0.26
16	182	20,565	2,759	0.646	37.3	2.9	3.4	0.5	1.087	59.43	34.31	2.67	3.13	0.46
17	220	24,000	3,058	1.070	74.3	12.5	*e*	*e*	*g* 1.938	55.21	38.34	6.45	....	... ...
18	272	45,404	2,697	0.535	28.3	0.6	1.2	0.2	0.838	63.84	33.77	0.72	1.43	0.24
19	278	115,921	2,667	0.503	30.0	1.7	1.1	0.2	0.833	60.38	36.02	2.04	1.32	0 24
20	287	49,686	3,079	0.491	21.7	2.4	0.5	0.2	0.739	66.44	29.36	3.25	0.68	0.27
21	310	256.345	2,667	0.551	39.6	2.1	16.6	1.5	1.149	47.95	34.46	1.83	14.45	1.31
22	156	24,563	3,333	0.405	25.7	6.0	3.2	0.6	0.760	53.29	33.82	7.89	4.21	0.79
23	197	44,407	3,333	1.333	38.5	5.5	1.6	0.5	1.794	74.30	21.46	3.07	0.80	0.28
24	217	87,384	3,333	1.861	34.6	4.8	2.7	0.6	2.288	81.34	15.12	2.10	1.18	0.26
25	304	63,977	3,333	1.500	33.0	3.9	2.5	0.5	1.899	78.99	17.38	2.05	1.32	0.26
26	248	22,577	3,200	2.408	41.9	12.0	1.8	0.3	2.968	81.13	14.12	4.04	0.61	0.10
27	310	99,508	2,875	0.928	45.4	1.2	3.0	0.1	1.425	65.12	31.86	0.84	2.11	0.07
28	165	23,094	3,335	1.265	42.5	8.7	4.4	0.4	1.825	69.31	23.29	4.77	2.41	0.22
29	264	36,970	3,319	1.259	28.3	8.1	3.7	0.4	1.664	75.66	17.01	4.87	2.22	0.24
30	201	14,198	3,333	1.160	46.3	7.0	4.6	1.3	1.742	66.59	26.58	4.02	2.64	0.17
31	28	3,918	2,969	2.704	45.4	3.4	4.2	1.5	3.249	83.23	13.97	1.05	1.29	0.46
32	28	6,848	2,817	2 530	27.9	2.0	1.2	1.7	2,868	88.21	9.73	0.70	0.77	0.59
33	28	2,601	2,637	2.321	27.4	3.3	1.7	1.0	2.655	87.42	10.32	1.24	0.64	0.38
34	92	10,531	2,659	2.281	18.0	3.2	3.7	1.1	2.541	89.77	7.08	1.26	1.46	0.43
35	310	29,851	2,421	1.458	13.9	0.8	11.0	....	1.715	85.01	8.11	0.47	6.41	....
36	365	88.516	2,700	2.498	19.3	*c*	5.2	*c*	2.743	91.06	7.04	....	1.90	....
37	365	91,098	3,053	1.398	24.2	*d*	4.2	3.3	*h* 1.715	81.52	14.11	.. ....	2.45	1.92
38	89	23,074	2,525	1.531	16.7	0.2	0.7	4.7	1.774	86.30	9.41	1.24	0.40	2.65
39	362	64,727	3,095	1.136	29.5	5.8	9.1	0.9	*i* 1.589	71.49	18.56	3.65	5.73	0.57
40	31	46,110	2,732	1.526	20.0	1.6	3.6	0.9	1.787	85.39	11.19	0.90	2.02	0.50
41	156	12,185	3,934	1.175	38.2	0.7	3.6	*e*	*f* 1.600	73.44	23.87	0.44	2.25	....
42	182	61,450	3,275	*a* 1.191	35.7	*a*	9.7	1.8	1.663	71.62	21.47	....	5.83	1.08
43	91	7,418	3,379	1.920	38.5	3.0	13.0	....	2.465	77.89	15.62	1.22	5.27	....
44	91	7,329	2,701	1.917	24.9	2.2	16.9	....	2.357	81.33	10.57	0.93	7.17	....
45	91	25.064	3.206	1.866	28.8	2.6	21.4	....	2.394	77.94	12.03	1.09	8.94	....

(*a*) The expenditures for officials and clerks are inseparably combined with those for coal. (*b*) Clerical work very slight and performed by clerk at another branch of same establishment. (*c*) The expenditures for officials and clerks and for taxes are inseparably combined with those for supplies and repairs. (*d*) The expenditures for officials and clerks are inseparably combined with those for taxes. (*e*) Not reported. (*f*) Not including taxes. (*g*) Not including supplies and repairs and taxes. (*h*) Including insurance and less 21.6c., the value of cinder, tar, and ammonia produced per ton. (*i*) Less 9.5c., the value of cinder, etc., produced per ton

In the United States it took, on the average, 3110 lbs. of coal (1.555 ton) to make 1 ton (2000 lbs.) of coke, and the cost was $1.66, of which the coal cost $1.21, or 73%, and the labor 35c., or 21.1%. On the Continent it took, on the average, 2655 lbs. (1.327 ton) of coal to make a ton of coke, and the cost was $2.28, of which the coal cost $2.02, or 89.28%, and the labor 19c., or 8.40%. In Great Britain it took, on the average, 3300 lbs. (1.65 ton) of coal to make a ton of coke, and the cost was $1.91, of which the coal cost $1.43, or 74.63%, and the labor 33c., or 17.24%.

The period covered by the investigation was that of 1889 and 1890, and during that time the price of Connellsville coke, free on board at the ovens, varied from $1.30 to $2.07, reaching in June, 1889, the very low price of $1.10.

Connellsville coke has been sold at the ovens more than once for less than $1.00 per ton, or less, it is said, than it cost to make it.

The following table gives the price of this coke, month by month, from 1881 to the close of 1892. During this period the highest price quoted was $2.15, throughout the greater part of 1890, and the lowest was 90c., in June, July, and August, 1883.

MONTHLY PRICES OF CONNELLSVILLE FURNACE COKE, F. O. B. OVENS.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
	$	$	$	$	$	$	$	$	$	$	$	$	$
1881..	1.50 to 1.75	1.50 to 1.75	1.50 to 1.75	1.60 to 1.75	1.60 to 1.65	1.60 to 1.65	1.50 to 1.60	1.60	1.60	1.60 to 1.65	1.60 to 1.65	1.60 to 1.70	1.62
1882....	1.70 to 1.80	1.70 to 1.80	1.70 to 1.75	1.70 to 1.75	1.65 to 1.70	1.50 to 1.65	1.35 to 1.50	1.35	1.25 to 1.35	1.25	1.25 to 1.35	1.15 to 1.35	1.50
1883....	1.15 to 1.20	1.20 to 1.10	1.05	1.05	0.95 to 1.05	0.90	0.90	0.90	1.00	1.00	1.00	1.00	1.01
1884....	1.00	1.00	1.00	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.08
1885....	1.10	1.10	1.10	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.18
1886....	1.20	1.20	1.35	1.35	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.42
1887....	1.50	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.96
1888....	1.75	1.75	1.25 to 1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.25	1.25	1.36
1889....	1.25	1.25	1.25	1.15	1.10	1.10	1.00 to 1.10	1.00	1.25 to 1.50	1.50	1.75	1.75	1.30
1890....	1.75	1.75	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.07
1891....	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.85	1.85	1.80	1.80	1.87
1892....	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90

The Chicago Coal Market.

The anthracite coal market has undergone a great change during the past twelve months. From Buffalo westward in January dullness was paramount, largely due to the weather conditions, the winter being very mild. The market was overstocked with dock and all-rail coal, and circular rates were entirely nominal, depending greatly upon the needs of the seller and the amount required by the buyer, but concessions were of a liberal character. The supply of all-rail was so large, and the outside demand for cars so great, that railroads were compelled to exact full demurrage charges. The Hadfield failure at Milwaukee had a depressing effect, as a large amount of car coal was thrown upon a market already greatly overstocked. Early in February there occurred the consolidation of the chief producers of anthracite, which, for the amount of capital and interests involved, rendered it the most important deal ever known in the history of the trade. The "combine" controlled about 70% of the output of anthracite, and completely revolutionized the manner of business as heretofore conducted. The first move made was to advance the price of coal and restrict deliveries to the month in which the contract was made. In the meantime, all through the spring there was a steady though quiet demand, not only from country but from city also, and the advanced circular was at first strictly adhered to. March, April, and May were good coal months, the weather being chilly and wet. The advancing quotations met with much opposition from jobbers and dealers, who were, however, powerless to protect themselves from the now hated combine. The purchase of docks and yards in good positions in various parts of the city by the Reading people was another departure, and many of the larger down-town dealers looked upon this new move as threatening their interests as retailers. The public press commenced an attack upon the consolidation, resulting in an inquiry being ordered before the grand jury, but of course without any result except expense to the county. At the opening of navigation in May the docks were fairly well cleaned up, owing to the steady though quiet demand from January to well into May. Vessel coal commenced to come forward, and receipts were large until the close of the season, Dec. 1. The usual stocking up by jobbers and country dealers was missing this year, and though some of the large dealers at Missouri and Mississippi points took in supplies, they were of moderate proportions only. On the whole, the summer months were characterized by a masterly inactivity, which continued well into the autumn. The steady advances made by the combine have almost ruined the Missouri River trade. Business generally throughout the fall was of a hand-to-mouth character, showing conclusively that country dealers mistrusted the ability of the combine to hold together. Natural gas is destined to play an important part in the domestic fuel department. A large number of private houses are now using it steadily for furnace heat, stoves, and kitchen ranges, and the number of consumers is steadily gaining. The aggregate tonnage displaced by this new fuel is large, and next season it will be still further increased. Crushed Connellsville coke will also play a not unimportant part as a substitute

for anthracite. The year closes with a quiet demand from all sources, and stocks are large.

Bituminous coal opened in 1892 with an overstocked market in all kinds, Eastern as well as Western, in strong contrast to the closing weeks, when coal is in heavy demand and operators rushed with orders which they are unable to fill. In January there was a fair demand for steam coal, but, there being a glut of all kinds, prices were weak and irregular. Many mine owners were impressed by the idea that Chicago could absorb all the coal shipped, and the inevitable consequence was a glutted market. Hence during the early months of the year prices were lost sight of in the endeavor to avoid demurrage charges. Shipments of grain fell off considerably, railroads did not take their usual quota of fuel, and office buildings, on account of the comparatively mild weather, used less steam for heating. Some little stocking up was done because of expected trouble with the miners in May, which helped the market to some extent. There were no strikes of any importance in Iowa, Indiana, or Illinois. During the summer business was active so far as regards annual contracts from railroads and other large consumers, and prices, though low, were only comparatively so. Early in the autumn the advancing price of anthracite gave some impetus to soft coal for domestic use, and country orders steadily increased. In September it became noticeable that cars were going to be scarce, which, together with the steadily increasing demand, began to make large dealers and consumers uneasy. In October and November soft coal of all grades and kinds was in better demand than supply, and in many instances "spot" coal was at a premium. Confiscation of coal by railroads was very common and caused shippers no end of trouble and anxiety. For several weeks there was a positive car famine, and some of the railroads restricted the mileage limit of their coal cars, which proved a fruitful source of annoyance to operators and consumers. The bituminous-coal market was never in better shape as regards price and demand than at the close of the year 1892.

Coke throughout the year has been in fair demand, and prices have held remarkably steady, especially on Connellsville. The latter part of the year has shown a steady though quiet growth of consumption. Crushed coke for domestic use, as prepared at Connellsville, is becoming an important factor as a substitute for hard coal. Consumption is quietly increasing, and all who have used it have nothing but words of praise. It is not expected that it will completely oust anthracite, but its influence will be felt, as it is not only cheaper, but there is less trouble in handling it in regard to ashes, and it is clinkerless. There is, without doubt, a future for this fuel.

New York Coal Stocks in 1892.

In Wall Street the year 1892 did not fulfill its early promises. Our financial policy did not meet with foreign approval, securities were sold back to us, and a large amount of capital was withdrawn, causing gold shipments so great as to

threaten a premium on that metal and the withdrawal from general circulation of many hundreds of millions—a contraction which would have been ruinous.

The New York Stock Exchange reports transactions in stocks about 20 per cent greater than in 1891, while the dealings in the coal stocks were three times as great, and amounted to about one fourth of the entire dealings in all stocks.

The great event of the year in the financial world was the Reading deal, whereby the Central Railroad of New Jersey and the Lehigh Valley Railroad were leased to the Reading Company. When it was completed good financial authorities expressed the belief that it would greatly benefit all the coal companies and the financial situation generally; but it has been a great disappointment, especially as the amount of coal marketed has been unprecedented, and at much higher prices, yet without anything like a corresponding increase in net earnings. This is especially true of the Reading Company. The fact is that this company has become so ponderous that a new, and therefore to a large extent inexperienced, management cannot successfully grasp the situation and direct its affairs. The greatest problem seems to be the economical mining and marketing of the coal. This would be a serious problem for our most experienced and successful coal men, and is, naturally, a still more difficult one for a management with only a railroad experience.

The attitude of the public and the "strikes" of politicians seem to make the success of such a combination impossible. The Central Railway of New Jersey has withdrawn from the Reading deal, finding that the laws of New Jersey would not sanction it.

Oppression of any kind can only be temporary. If the coal combination oppresses the consumer, there will be a substitute for the present unscientific methods of consuming anthracite coal in domestic use. This coal is a very expensive luxury as now consumed, and is but a small fraction of the entire fuel resources of this country. A year or two of very high prices might prove a blessing rather than a curse by causing the introduction of new means of furnishing heat to our houses, which is the main use of anthracite coal to-day. Already the H. C. Frick Coke Company, following the lead of the St. Bernard Coal Company, is in the field with crushed and sized coke, with prospects of its taking the place of anthracite coal to a very large extent.

The Reading Railroad has furnished Wall Street with many sensations, and it is safe to say that it is not yet through doing so. It will be a football until it settles into a powerful and successful ownership, dominated by people of undoubted ability and financial strength. At this writing it is known that the company has declared full interest on all of its income bonds, and is claiming a surplus for the stock. It is also pretty well understood that there has been some extensive financiering done to pay said interest. Fortunately for the company, the severity of the winter caused an enormous consumption of coal and at the same time a decreased production and movement, and may prevent what otherwise might be disaster to so aggressive a management.

The transactions in Reading stock during the year aggregated 20,389,380 shares, at \$38@\$65. It was confidently stated by insiders that \$90 would be reached by Christmas, but it is now clear that some shrewd and strong parties in the deal slipped out at \$60 or over and never went back permanently.

Early in the year Delaware, Lackawanna and Western sold at $138\frac{1}{8}$, reaching on the boom $167\frac{1}{2}$. It showed an increase of 15% over last year's closing, and apparently has greatly benefited by the Reading deal. The transactions amounted to 1,615,586 shares. This stock is likely to be a fancy investment so long as the present management and policy prevails.

Delaware and Hudson, with sales of 394,404 shares, ranged between $122\frac{7}{8}$ and $149\frac{1}{2}$, closing at $134\frac{1}{2}$—a gain of $11\frac{1}{2}$ over the closing of 1891.

PRICES OF COAL STOCKS IN NEW YORK DURING 1892.

Name of Company.	January.		February.		March.		April.		May.		June.	
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Cambria Iron	74.00	......	80.00	75.50	80.00	......	77.00	75.00	77.00	76.50	77.00	76.50
Cameron Coal	......	......	2.00	1.63	......	......	......	......	......	......	......	......
Col. & Hocking Coal	18.25	15.00	17.00	16.50	16.50	15.75	......	......	12 00	......	......	......
Col. C. & I.	39.50	35.88	38.00	35.50	37.75	32.50	33.13	30.13	36.00	28.25	36.00	32.25
Consolidation Coal	......	......	28.00	26.00	28.50	......	......	......	......	......	29.00	28.00
Del. & Hudson Canal	129.00	122.88	145.25	124.50	145.75	137.00	149.50	138.13	147.50	141.25	142.75	136.00
D., L. & W. R. R.	148.25	138.13	167.50	144.00	166.00	156.38	165.00	154.00	159.88	156.25	159.38	154.50
Hocking Valley	32.25	29.50	33.13	30.75	31.75	29.50	34.25	29.63	40.00	33.25	38.50	35.75
" " pref.	......	......	......	......	71.00	70.00	76.00	70.38	80.50	74.13	81.60	76.75
Hunt & Broad Top	27.75	25.50	33.00	26.75	34.50	30.50	37.25	33.00	37.00	33.00	36.00	35.38
" " pref.	49.00	46.50	53.75	46.50	54.75	51.00	55.00	53.38	55.13	54.50	55.13	54.13
Lehigh Coal & Nav.	49.25	48.50	55.13	48.50	54.50	53.38	54.75	53.13	54.25	52.50	54.00	52.75
Lehigh Valley	51.25	50.25	62.50	50.50	59.00	56.38	60.00	56.75	61.38	58.50	61.50	60.25
Mahoning Coal	......	......	77.50	......	......	......	......	......	......	......	......	......
" " pref.	......	......	100.00	......	112 00	110.00	112.50	......	......	......	......	......
Maryland Coal	25.25	24.50	25.50	23.75	27.00	25.00	25.00	......	26.00	24.00	24 88	24.75
Morris & Essex	145.25	143.13	146.50	145.00	147.50	144.50	148.00	145.50	150.00	148.00	148.00	145.25
New Central Coal	11.38	10.00	13.00	11.75	......	......	......	......	10.00	9.50	11.00	......
N. J. C. R. R.	117.25	111.50	145.00	178.88	144.00	136.50	143.00	135.00	142.00	137.63	140.00	135.25
N. Y., Susq. & West	13.00	10.50	14.63	11.00	14.25	12.50	13.25	11.50	15.88	11.63	15.50	13.75
" " " pref.	50.25	41.50	59.25	49.00	60.00	54.75	58.50	55.00	66 00	55.00	66.50	63.50
Norfolk & West. R. R.	18.00	16.00	15.00	14.13	14.75	14.13	14.63	14.00	13.00	12.75	11.00	......
" " " pref.	56.00	49.75	51.50	49.00	51.50	49.00	50.50	47.75	48 00	46.25	46.50	45.25
Pennsylvania Coal	......	......	......	......	......	......	......	......	......	......	......	......
" R. R.	56.88	55.88	56.13	54.88	55.38	54.50	58.38	54.88	56.38	54.38	55.75	54.88
Phila. & Reading R. R.	42.88	38.00	65.00	40.75	59.63	52.50	62.38	53.63	62.00	58.75	61.25	58.13
Tennessee C. & I.	44.88	40.50	47.00	41.00	50.25	43.00	47.75	44.00	47.00	40.13	41.50	34.00
" " pref.	97.00	......	92.00	......	106.00	97.50	108.00	102.00	108 00	105.00	105.00	......

Name of Company.	July.		August.		September.		October.		November.		December.		Sales.
	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Cambria Iron	77.00	......	77.00	......	......	......	......	......	76.00	......	......	......	883
Cameron Coal	......	......	......	......	......	......	......	......	......	......	......	......	200
Col. & Hocking Coal	......	......	......	......	......	......	......	......	12.00	......	......	......	8,715
Col. C. & I.	36.75	34.13	39.75	31.50	43.25	36.00	43.75	40.50	43.00	38.38	42.75	38.88	369,039
Consolidation Coal	......	......	......	......	......	......	29.75	29.00	29.00	28.00	......	......	1,818
Del. & Hudson Canal.	138.50	135.00	139.25	135.75	133.50	125.00	137.00	133.25	133.63	129.63	134.75	127.50	394,404
D., L. & W. R. R.	160.00	154.25	159.00	155.50	156.00	150.00	155,00	152.75	154.38	150.13	155.50	147.00	1,615,586
Hocking Valley	36.50	34.25	36.25	32.25	32.75	30.75	31.00	27.88	31.38	27.13	30.75	27.00	337,027
" " pref.	76.88	74.00	77.50	74.00	74.50	73.13	77.00	72.00	74.25	70.25	74.50	74.00	19,593
Hunt & Broad Top	35.38	34.25	34.00	32.00	35.75	31.00	40.50	35.88	42.00	40.25	41.13	40.50	57,692
" " pref.	55.13	53.50	54.00	53.50	56.00	52.50	56.00	55.00	57.25	55.00	56.00	......	32,509
Lehigh Coal & Nav.	54.13	52.75	54.50	53.63	54.00	53.00	54.25	53.38	54.88	52.25	53.75	52.88	101,793
Lehigh Valley	62.00	60.00	62.00	59.88	60.25	58.00	59.50	56.25	58.00	57.00	58.50	57.00	285,536
Mahoning Coal	......	......	......	......	......	......	......	......	100.00	......	......	......	800
" " pref.	......	......	......	......	......	......	......	......	110.00	108.50	......	......	914
Maryland Coal	24.75	23.00	24.00	23.00	23.00	......	21.00	......	24.00	......	......	......	4,681
Morris & Essex	149.00	......	155.00	149.50	154.75	152.00	151.00	......	154.25	151.00	154.00	......	4,224
New Central Coal	......	......	11.50	......	......	......	......	......	11.00	......	10.75	......	1,890
N. J. C. R. R.	139.00	135.00	137.50	132.00	133.38	125.75	133.00	127.25	128.50	125.38	127.25	122.50	298,222
N. Y. Susq. & W.	15.25	13.75	16.25	14.75	16.63	13.75	20.25	16.00	20.75	17.50	18.00	15.50	260,193
" " " pref.	66.38	60.00	69.75	66.00	66.50	63.00	73.50	65.00	74.00	69.00	70.50	64.50	144,717
Norfolk & West. R. R.	11.50	11.00	11.88	11.50	11.00	9.00	11.25	10.25	10.50	......	10.50	10.00	11,924
" " " pref.	45.00	43.00	45.13	43.00	42.00	37.25	40.50	39.25	41.00	39.25	39.50	37.25	22,011
Pennsylvania Coal	......	......	300.50	300.00	......	......	......	......	......	......	......	......	232
" R. R.	55.38	54.25	55.00	54.50	55.50	53.88	56.00	55.38	55.75	53.00	54.50	53.13	359,446
Phila. & Reading R. R.	61.25	58.63	61.75	56.25	58.75	52.88	59.88	56.50	58.50	53.38	56.13	50.75	20,389,380
Tennessee C. & I.	36.00	31.50	35.75	33.00	36.00	32.00	39.00	35.00	38.25	35.00	37.75	34.25	390,882
" " pref.	100.00	......	100.00	94.00	102 00	100.00	......	......	105.00	......	......	......	3,494
Total sales													25,098,212

Lehigh Valley, under the stimulus given by consolidation with Reading, was unusually active, the sales amounting to 285,536 shares. In January this stock sold at \$50¼, and advanced \$12¼ before the end of February, selling at \$56¼ in October, after which there was a slight improvement.

Cameron Coal will not disappear entirely, although it came very nearly doing so last year, the sales amounting to only 200 shares at nominal prices.

Colorado Coal and Iron was quite active during the year, the sales amounting to 369,039 shares at \$28¼@\$43¾. The company's financial condition was greatly improved, and by its consolidation with the Colorado Fuel Company there is good reason for expecting improved business results.

Columbus and Hocking Coal and Iron was very quiet during most of the year, with sales of 8715 shares at \$12@\$20⅛. This company has been largely instrumental in the attempt to form a combination to sell all the coal of the district through a general agency. The officers say that the company is free of floating debt, and under the new arrangement will be able to pay a fair dividend this year on the common stock. They are confidently predicting much higher prices for the stock.

Columbus and Hocking Valley Railroad has been fairly active, selling up to \$40, and closing at \$28⅞—a loss of 1⅛ per cent for the year. The dealings aggregated 337,027 shares. If the new coal pool should prove successful, this stock will probably sell higher.

Maryland Coal, with transactions of 4681 shares at \$21@\$27, shows a slight improvement for the year. The company continues to pay dividends, and its policy, not yet made public, is likely to increase them considerably.

The dealings in Consolidation Coal amounted to 1818 shares at \$26@\$29¾. It has been a great many years since Mr. Alan Campbell retired from the presidency of this company, and millions of tons of coal have been taken from the company's assets without any appreciation in the company's stock.

Pittsburg Coal in 1892.

(From our Special Correspondent.)

In the year 1892 there were no shipments by water in the last six months, and the year's shipment is the lowest since 1887, being 13,307,000 bushels (532,280 net tons) below that of 1891, and 46,544,000 bushels (1,861,760 tons of 2000 lbs.) below the great output of 1888.

The Monongahela Valley miners have been on a strike since the 1st of July, and now, although no coal has been shipped during the last four months, there are only from 5,500,000 to 6,000,000 bushels loaded, and the pools are crowded with empty barges. The coal-miners along the railroads pay 3c. per bushel for mining, and the river men are willing to pay the same amount, but cannot yield to the demand for 3½c.

The time is coming when, by the use of coal-mining machinery, the dependence on hand miners will be much weakened. One of the large operators is now putting in machinery of this kind in an extensive mine in the fourth pool.

The lower markets are reported fairly well supplied with coal, in spite of the limited amount that has left Pittsburg during the year.

Coal shipments by the Ohio River for the last 12 years are given in the following table in bushels and in net tons of 25 bushels to the ton:

TWELVE YEARS' COAL SHIPMENT BY OHIO RIVER.

Year.	Cincinnati.		Louisville.		Total.	
	Bushels.	Net Tons.	Bushels.	Net Tons.	Bushels.	Net Tons.
1881	25,400,000	1,016,000	37,396,000	1,495,840	62,886,000	2,515,440
1882	34,462,000	1,378,480	36,679,000	1,467,160	71,139,000	2,845,560
1883	31,533,000	1,261,320	56,462,000	2,258,480	87,990,000	3,519,600
1884	24,631,000	985,240	30,801,000	1,232,040	55,432,000	2,217,280
1885	32,590,000	1,303,600	42,334,000	1,693,360	74,921,000	2,996,840
1886	33,229,000	1,329,160	38,435,000	1,537,400	91,646,000	3,665,840
1887	20,770,000	830,800	35,973,000	1,438,920	56,743,000	2,269,720
1888	51,339,000	2,053,560	58,513,000	2,340,520	109,652,000	4,386,080
1889	30,360,000	1,214,400	37,895,000	1,515,800	68,255,000	2,730,200
1890	32,616,000	1,304,640	51,054,000	2,042,160	91,820,000	3,672,800
1891	28,125,000	1,125,000	48,290,000	1,931,600	76,415,000	3,056,600
1892	24,339,000	973,560	38,749,000	1,549,960	63,108,000	2,524,320
Total	369,394,000	14,775,760	512,581,000	20,503,240	881,975,000	35,279,000

Tests of the Heating Power of Coals.

By William Kent, M.E.

The researches of Scheurer-Kestner and Ch. Meunier-Dollfus, in 1868, on the heating power of various European coals,* have long been considered the most reliable work ever done in coal calorimetry. A similar research has recently been conducted by Monsieur P. Mahler, under the auspices of the *Société d'Encouragement pour l'Industrie Nationale,* and with its financial assistance to the extent of 3000 francs, the results of which are worthy of being placed with those of Scheurer-Kestner and Meunier-Dollfus' work as a standard of reference. M. Mahler's report is published as a pamphlet extract from the *Bulletin* of the Société, occupying 73 pages quarto, with two large plates. It is entitled *Contribution à l'Etude des Combustibles: Détermination Industrielle de leur Puissance Calorifique. Par P. Mahler, Ingénieur Civil des Mines, etc.* It is altogether an admirable paper, not only on account of the results it makes known, but also in its method of treatment, and fully warrants the high commendation given it in a preface by MM. Carnot and Chatelier, a Committee of Chemical Arts of the Société.

The method adopted by M. Mahler for determination of the heating power of coals and other fuels was the use of a modified form of the "calorimetric bomb" of MM. Berthelot and Vielle, described in the *Annales de Physiques et de Chimie* in 1881 and 1885, together with elementary and proximate analyses of the fuels, by methods which are described at length. The bomb, with its auxiliary apparatus, is clearly shown in the figures.

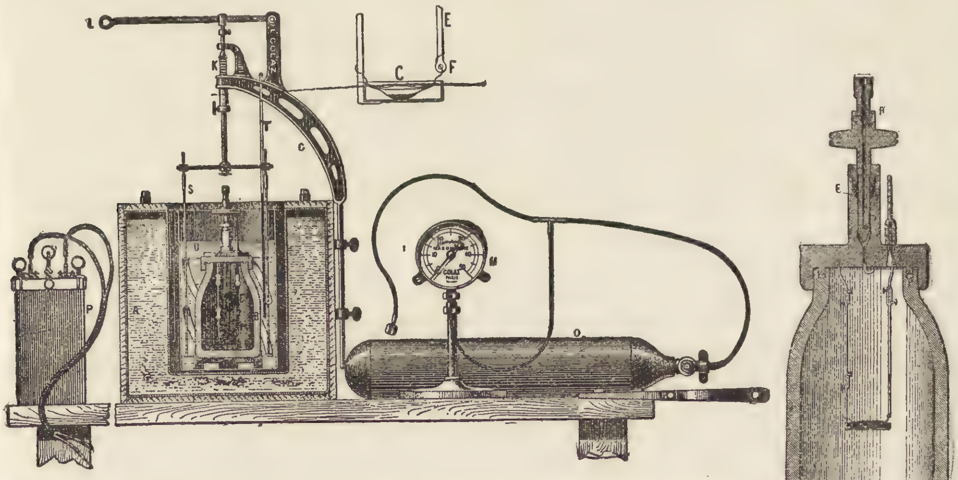


Fig. 1. Apparatus for Determining the Commercial Heating Power of Fuel.

The bomb consists essentially of a shell of forged Siemens-Martin steel, of 654 cubic centimeters capacity. Its walls are eight millimeters in thickness, and its weight is about four kilos. Its exterior surface is nickel-plated, and its interior

* See paper by M. L. Gruner, translated by R. P. Rothwell, on "The Classification and Heating Power of Coals," *Engineering and Mining Journal*, July 18, 1874, *et seq.*, and a review of the same by the present writer in the same publication, Oct. 31, 1891.

is coated with a white enamel to protect it from the corrosive action of the gases of combustion. This coating is very thin, and offers no appreciable resistance to the transmission of heat.

As shown in Figs. 1 and 2, the combustible whose calorific power is to be determined is placed in a platinum capsule suspended in the interior of the shell, and the shell is immersed in water in a calorimeter made of thin sheet brass, which is surrounded by a non-conducting envelope. The uniform weight of 2.2 kilos of water is used, and the quantity of combustible used is generally 1 gram. The shell is filled with oxygen gas under a pressure of 20 to 25 atmospheres, the stopper tightly closed, and the combustible ignited by passing an electric current through a fine iron wire placed in the combustible. The combustion which takes place is complete and almost instantaneous. The heat disengaged is transmitted, without any loss, to the water in the calorimeter, where its quantity is measured by a delicate thermometer, the water being thoroughly stirred by the spiral agitator shown in Fig. 1. On account of the rapidity of the experiment the greater part of the corrections usually necessary in calorimetric work are negligible; for example, those due to the evaporation of water and to the variations in temperature of the room. The correction for the "water equivalent" of the apparatus itself was determined by experiment to be 481 grams, which is to be added to the weight of water used in the calorimeter, or 2200 grams. The correctness of this figure, 481 grams, was further proved by experiments on the combustion of naphthaline, the calorific power of which had been determined by a great number of trials in the College of France to be 9692 calories per kilogram. Three experiments with the bomb gave results for 1 gram 9.6855, 9.6855, and 9.6935 calories, a mean of 9.688 calories.

In conducting an experiment, the observer notes the temperature from minute to minute for four or five minutes before the ignition, while constantly stirring the water; then having made the ignition, the temperature is noted one half minute and one minute afterward, and then from minute to minute until the temperature is reached from which it begins to decrease regularly. This temperature is the maximum. The observation is continued about five minutes longer to determine the law followed by the thermometer after the maximum, and the consequent correction to be applied for cooling of the calorimeter by radiation. After opening the bomb its interior is washed with distilled water so as to collect the liquid nitric acid which may be formed during the explosion. The amount of this acid is determined volumetrically by titrating with a solution of potash. All the data being thus obtained, the calculation for calorific power Q of the combustible is made as follows:

Let D be the difference of temperature observed;
a, the correction for cooling;
P, the weight of water in the calorimeter;
P', the equivalent in water of the shell and its accessories;
p, the weight of nitric acid $(N_2O_5H_2O)$;
p' the weight of the spiral of iron wire;
0 cal. .23 is the heat of formation of 1 gram of nitric acid; and
1 cal. .6 is the heat of combustion of 1 gram of iron.

We have

$$Q = (D + a)(P + P') - (0.23p + 1.6p').$$

The following shows the figures obtained in an industrial determination of the heating power of a sample of the well-known Nixon's Navigation Coal, from South Wales.

Analysis gave:

Fixed carbon, without ash	86.30
Volatile matter, without water	10.15
Hygroscopic water	1.85
Ash, by calcination	1.70
	100.00

Preliminary Period.		Combustion.		After Combustion.	
0 minutes,	15°.20	3½ minutes,	16°.60	7 minutes,	18.32
1 "	15°.20	4 "	17° 92	8 "	18.30
2 "	15°.20	5 "	18°.32	9 "	"
3 "	15°.20	6 "	18°.34	10 "	"
			maximum	11 "	18.26

Pressure of oxygen, 25 atmospheres,

$$a = \frac{18^\circ.34 - 18^\circ.26}{5} = 0^\circ.016 \text{ per minute.}$$

Difference of temperature observed	3°.140
Correction 4-5, 5-6; $0.016 \times 2 =$	0 .032
Correction 4-3½	0 .005
Difference corrected	3 .177; say 3.18.

We have then, for the quantity of heat disengaged, $(2200 + 481)$ grams $\times$ $3^\circ.18 = 8.5256$ calories; weight of iron wire, 0 gr. $025 \times 1.6 = 0.040$ calories; nitric acid found, $0.15 \times 0.23 = 0.0345$—total, 8.4511, or for one kilogram of the coal, 8451 calories.

The concordance of the results of different experiments with the same coal is shown in the following:

	1st.	2d.	3d.
Flaming coal from Montvic	7.790	7.806	7.817
Gas coal from Commentry	7.870	7.868	7.868
Gas coal from Montrambert	8.268	8.243	8.282

The condensed results obtained by M. Mahler from experiments on a large number of coals are given in Table I. herewith. The last three columns have been added by the writer to show a comparison of the differences between the actual calorific powers of the several coals as determined by the calorimetric bomb and the calculated power according to Dulong's formula as modified by Mahler and according to Mahler's own formula. Mahler lays stress upon the fact that Dulong's formula generally gives results which are below the actual, which observation was made originally by Scheurer-Kestner and Meunier-Dollfus. The three columns of differences, however, seem to show that Dulong's formula is on the average as near to being correct as is Mahler's. In two classes, anthracites and anthracitic, and fat gas coals, the average figures found by Dulong's formula are nearer to the actual results than are the figures from Mahler's formula, while the reverse is the case in the other two classes, fat and semi-fat coals and flaming coals. The average of the 31 coals shows that

TABLE I.—HEATING POWER OF COALS. RESULTS OF P. MAHLER'S CALORIMETRIC TESTS.

Number.		Coal Dry and Free from Ash.							Comparisons.		
		Percentage of Fixed Carbon.	Composition.			Heating Power.					
			C	H	O+N	Actual Calories.	Theoretical.		Dulong's with Actual.	Mahler's with Actual.	Mahler's with Dulong's.
							Dulong's Cals.*	Mahler's Cals.			
	ANTHRACITE AND ANTHRACITIC.										
1	Pennsylvania	97.00	95.37	2.20	2.43	8256	8462	8450	+206	+194	−12
2	De la Mure (Grande Couche)	97.25	95.24	1.50	3.26	8216	8173	8172	−43	−44	−1
3	Hay-Duong (Tonkin)	96.83	92.86	2.16	4.99	8121	8130	8152	+9	+30	+22
4	Kebao	94.80	93.46	3.07	3.48	8532	8528	8531	−4	−1	+3
5	Commentry	96.81	91.49	3.12	5.39	8456	8333	8360	−123	−96	+27
6	Blanzy, Puits Ste.-Barbe	94.	90.	3.17	6.83	8203	8169	8215	−34	+12	+46
7	Grande Combe, Puits Petassas	93.29	91.46	3.95	4.59	8540	8653	8670	+113	+130	+17
8	Creusot	89.56	92.39	3.78	3.83	8687	8704	8712	+17	+25	+8
							Average ..		+18	+19	
	FAT AND SEMI-FAT (Demi-grasse).										
9	Demi-grasse, d'Anzin, Fosse St. Marc	85.92	91.26	4.27	4.48	8656	8751	8767	+95	+111	+16
10	" " Grande Combe	86.62	91.19	4.46	4.35	8756	8817	8832	+61	+76	+15
11	" " Roche-la-Molière	86.00	90.11	4.38	5.51	8767	8651	8681	−106	−86	+30
12	" " Aniche	88.07	90.10	4.40	5.49	8834	8659	8688	−175	−146	+29
13	Grasse, Anzin, great vein	78.49	89.20	4.67	6.14	8574	8651	8689	+77	+115	+38
14	" Ronchamp	76.77	88.89	4.84	6.27	8797	8678	8717	−119	−80	+39
15	" Lens	80.50	90.03	4.80	5.17	8839	8805	8829	−34	−10	+24
16	" Carmaux	78.25	87.84	4.87	7.30	8639	8559	8611	−80	−28	+42
17	" Roche-la-Molière	77.15	89.53	4.84	5.63	8867	8757	8788	−110	−79	+31
18	" Saint-Étienne	79.16	89.23	5.03	5.74	8857	8796	8829	−61	−28	+33
19	" Mines de Portes (Gard)	80.71	86.52	4.84	8.64	8667	8382	8452	−285	−215	+70
							Average .		−66	−34	
	FAT GAS COALS.										
20	Bethune	69.59	87.03	5.37	7.60	8668	8654	8710	−14	+42	+56
21	Lens.	69.20	87.26	5.44	7.30	8749	8705	8758	−44	+9	+53
22	Firminy	67.98	85.39	5.58	9.13	8573	8524	8601	−49	+28	+77
23	Montrambert	65.73	84.52	5.54	9.94	8598	8407	8494	−191	−101	+87
24	Commentry	60.04	85.66	5.60	8.73	8408	8573	8644	+165	+238	+71
25	Wigan, Lancashire	68.36	88.57	5.72	5.72	8768	8979	9011	+211	+243	+40
26	Cannel Coal, Niddrie	47.	83.79	6.57	9.63	8431	8717	8800	+286	+369	+83
							Average ..		+9	+117	
	FLAMING COALS. LIGNITIC.										
27	Montvic	62.93	83.95	5.64	10.42	8570	8371	8465	−199	−105	+74
28	Blanzy (Puits Ste.-Marie	68.05	84.26	5.27	10.46	8350	8271	8364	−79	+14	+93
29	Decazeville (Bourran)	64.20	83.17	5.68	11.14	8270	8294	8397	+24	+127	+103
30	Blanzy (Puits Ste.-Eugénie)	60.61	81.54	5.64	12.83	8083	8072	8197	−11	+114	+125
31	Decazeville (Tramont)	58.77	78.72	5.67	15.61	7837	7735	7897	−102	+60	+162
							Average ..		−74	+42	
				Average of 4 above classes					−26	+26	
	LIGNITES.										
32	Terre de Feu	47.23	71.01	5.94	23.05	7039	6882	7141	−157	+102	+259
33	Trifail (Styria)	49.66	69.24	5.06	25.71	6616	6317	6610	−299	−6	+293
34	Vaurigard	50.05	66.36	5.01	28.63	6076	5938	6270	−138	+194	+332
35	TURF FROM BOHEMIA	31.07	57.21	5.96	36.82	5903	5169	5609	−734	−294	+440
	WOOD.										
36	Partially dry, Sapin de Norvège	......	51.08	6.02	42.90	4828	4428	4947	−400	+119	+519
37	Bois de Chêne de Lorraine	......	50.44	5.88	43.69	4689	4293	4823	−396	+134	+430
38	Cellulose, $C_{12}H_{10}O_{10}$	......	44.41	6.17	49.39	4200	3617	4264	−583	+64	+637

* Dulong's formula; $Q = \frac{1}{100}\left[8080 + 34{,}500\left(H - \frac{O}{8}\right)\right]$.

Dulong's formula, slightly modified by Mahler: $Q = \frac{1}{100}\left[8140 + 34500\left(H - \frac{(O + N) - 1}{8}\right)\right]$. It may be put under the form $Q = \frac{1}{100}[8140C + 34500H - 4312.5[(O + N) - 1]$.

Mahler's formula: $Q = \frac{8140C + 34500H - 3000(O + N)}{100}$.

Dulong's formula gives only 26 calories less than the actual results, while Mahler's formula gives 26 calories greater than the actual. The difference of 26 calories in an average total of over 8000 calories is surprisingly small. The

maximum differences between the results calculated by Dulong's formula and the actual are plus 286 and minus 285 calories, and the maximum difference between the results calculated by Mahler's formula and the actual are plus 369 and minus 215 calories. The maximum difference between Dulong's formula and the actual result in any single case is a little over 3%, and between Mahler's formula and the actual is over 4%. For all practical purposes, therefore, either formula may be accepted as being as nearly correct as any formula expressing the relation between the calorific power of a coal and its chemical analysis can possibly be. Dulong's formula has the advantage of being more strictly a theoretical formula, based merely upon the observed heating power of the two elements, carbon and hydrogen, and the assumption that the oxygen renders unavailable for heating power one eighth of its weight of hydrogen, while Mahler's formula introduces a coefficient, 3000, which is entirely empirical, and based only on his own observations.

Mahler modifies Dulong's formula slightly by using 8140, Berthelot's recent determination of the heating power of carbon, instead of 8080, the figure formerly used, and by taking account of the content of nitrogen, to which there can be no objection.

The heat of combustion of even a simple substance is to a certain extent indefinite, for it may vary with the allotropic form of the substance. Thus for carbon Berthelot gives the following figures:

Heat of combustion of the diamond, 7859 calories; of black diamond (bort), 7860.9 calories; of graphite, 7901.2 calories; of amorphous wood-charcoal, 8137.4 calories.

While, therefore, either Dulong's or Mahler's formula may be expected to give the heating power of a coal from its analysis within a possible limit of error of 3%, still, as is said by Mahler, from the scientific point of view, in the actual state of knowledge on the question, we cannot construct a formula which shall express rigorously the relation between the composition and the heating power of combustibles.

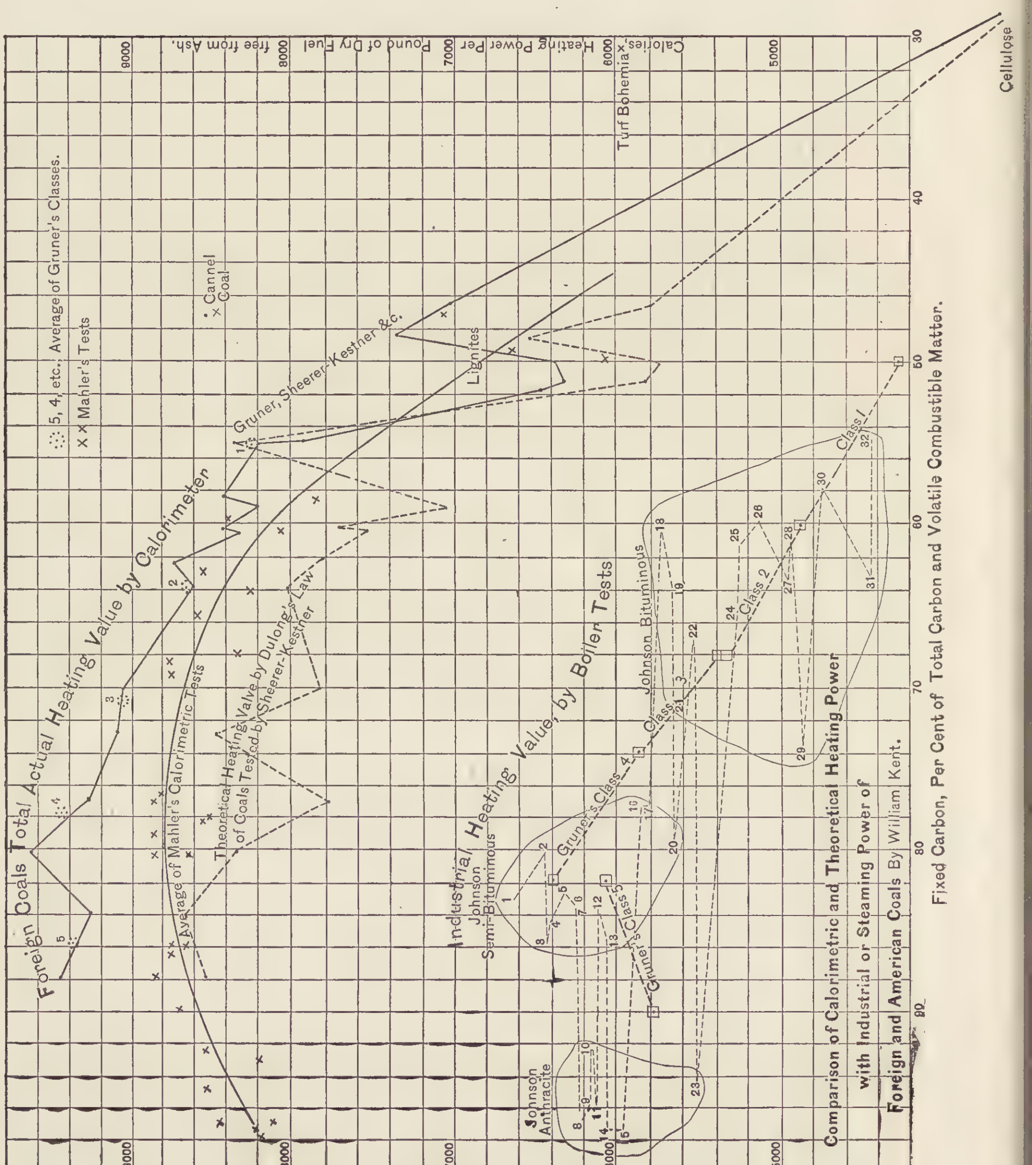
Mahler uses the commonly accepted figure 34,500 for the heat of combustion of hydrogen, with condensation of the water formed.

In summarizing his research, M. Mahler concludes as follows: "My experiments appear to show that an establishment which estimates the value of a coal by its elementary composition has a good chance of finding a figure sufficiently near to the truth, except in the case of extra-hydrogenous coals of the nature of cannel coal. Still it is difficult to determine with precision the hydrogen and the carbon contained in a coal; it is infinitely more simple to have recourse to a calorimeter, which permits us to appraise the value of all the combustibles without exception, and with incomparable precision."

M. Mahler does not make any comparison, except in a few instances, between the results obtained by him and those obtained by earlier experimenters on coals of similar compositions. The tables of comparative results of Scheurer-Kestner, Johnson, and others, and the plotted diagram made therefrom, heretofore published by the writer,* offer a convenient means of making a comparison with

* *Engineering and Mining Journal*, Oct. 31, 1891.

Mahler's results. The tables referred to are reprinted herewith for convenient comparison (Tables II. and III.), and the diagram is reproduced, with the addition to it of Mahler's results.



COMPARISON OF RESULTS OF JOHNSON'S TESTS OF AMERICAN COALS WITH RESULTS OF EUROPEAN COAL TESTS.

Probably the most carefully conducted and extensive series of tests of European coals on record is that of Scheurer-Kestner and Ch. Meunier in 1868.*

Gruner divides the bituminous coals into five classes, as follows :

1. Dry or semi-bituminous anthracite coals.
2. Short-flaming, caking, or coking coals.
3. True coking coals, or smiths' coals.
4. Long-flaming, caking, or gas coals.
5. Long-flaming, dry coals.

The range of chemical analysis, theoretical heating power, and value for steam-making of European coals, as determined by boiler tests, is given in Table II., in which are arranged a number of tests and analyses taken by Gruner from Scheurer-Kestner's reports. The total heating power (in calories†) is that found by tests with Favre and Silberman's calorimeter, and it is notably higher than the theoretical power obtained by Dulong's formula, except in the case of the highly bituminous lignite from Bohemia, which is said to resemble a petroleum.

The next to the last column in the table gives the range of the industrial heating power, or steaming power, in calories of the several classes of Gruner, as determined by boiler tests, and the last column the per cent of this so-called industrial heating power to the total heating power as determined by calorimeters. From this column it appears that the short-flaming, caking, or coking coals containing on an average about 78 parts of fixed carbon in 100 of total combustible have a higher ratio of industrial to total heating power than the anthracite coals, and a much higher ratio (as 65 to 55) than the long-flaming, dry coals, averaging 55 parts of fixed carbon in 100 of total combustible. This agrees with Johnson's general result, in which it was found that the semi-bituminous coals gave better results in proportion to their chemical composition than the anthracites, and very much better results than the highly bituminous coals.

In this table the results are figured upon pure and dry coal, that is, the ash and moisture have been deducted and the calculation made on the basis of the ratio which the fixed carbon bears to the total of fixed carbon and volatile combustible alone. This is a more scientific method than that which includes the moisture and ash, which may be called accidental impurities, and leads to less confusion and to more correct conclusions concerning the influence of the volatile combustible upon the heating power.

In order to make a comparison between the figures given in this table and the results of Johnson, it is necessary to recalculate the latter on the basis of percentage of fixed carbon to total combustible, to express the heating power in calories, and to make a correction of Johnson's figures for what appears in the light of Regnault's researches to be the incorrect figure he adopted for the latent heat of the evaporation of water at 212°.

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* Reported in the *Bulletin de la Société Industrielle de Mulhouse.* An excellent study of these tests, with others, is that by M. L. Gruner in his papers on "The Classification and Heating Power of Coals," translated from the French by R. P. Rothwell, and published in the *Engineering and Mining Journal*, July 18, 1874, *et seq.*

† A calorie here is $\frac{9}{5}$ that of a British thermal unit, or the heat required to raise 1 lb. of water 1° C.

This figure was 1030 British thermal units, while the experiments of Regnault gave 966. Johnson's figures must therefore be multiplied by $\frac{1030}{966}$ or 1.066. The result of this recalculation and correction is given in Table III.

The principal results shown in Tables II. and III. are plotted in the accompanying diagram, showing a comparison of the calorimetric and theoretical heating power, and the industrial or steaming power of the coals tested by Scheurer-Kestner, and of the average of Gruner's five classes, with the results of Johnson's tests. The upper line of the diagram shows the total heating power of the coals tested by Scheurer-Kestner, arranged from left to right in the order of their percentages of fixed carbon to total combustible. The five numbered stars in the line show the position of the averages of Gruner's classes. The next lower line in the diagram shows the theoretical heating value, according to Dulong's law, of the coals tested by Scheurer-Kestner. This value is less than the total value in every case except that of the bituminous lignite.

Johnson's tests group themselves into three distinct classes. They are numbered from 1 to 32, in the order of their steaming value. The extreme irregularity of these tests is clearly shown by the position of the numbers. The five short inclined lines included among Johnson's groups represent the range of the industrial value of Gruner's five classes. They show as close an agreement as can be expected with the results of Johnson, and indicate that the efficiency of the coals in actual trial upon which Gruner's figures are based was about as low, on an average, as the efficiency shown in Johnson's tests. This efficiency, as shown in the last column of Table II., ranged from 65% down to 55% of the total heating value.

TABLE II.—HEATING POWER OF COALS.

According to Scheurer-Kestner and others, as collated by Gruner. Arranged in order of per cent of fixed carbon in dry fuel free from ash.

Description of Fuel.	Per Ct. Fixed Carbon per 100 Fuel.	Elementary Composition.			Heating Power.			
		C.	H.	O + N.*	Actual	By Dulong's Law.	Industrial.	
					Calories.	Cal.	In Boilers.	P. Ct. Total
Anthracite coal from the Creusot	88.1	92.36	3.66	3.98	9456	8552	....	......
Gruner's Class 5. Dry or semi-bituminous anthracitic coals	82-90	90-93	4.5-4	5.5-3	9200-9500	......	5760-6080	63.9
Dry-burning coal, St. Paul du Creusot	84.2	90.79	4.24	4.97	9263	8683	....	......
Short-flaming or fat coal, Chaptal du Creusot	80.4	88.48	4.41	7.11	9622	8363	....	......
Gruner's Class 4. Short-flaming, caking or coking	74-82	88-91	5 5-4.5	6.5-5 5	9300-9600	......	5888-6400	65.0
Caking coal. Auzin	77.2	84.47	4.21	11.32	9257	7789	....	......
Caking coal. Ronchamp	73.0	88.32	4.79	6.89	9077	8494	....	......
Gruner's Class 3. True caking coals, or Smith's coals	68-74	84-89	5-4.5	11-5.5	8800-9300	.....	5376-5888	62.2
Caking coal. Denain	70.3	83.94	4.43	11.63	9050	7810	....	......
Long-flaming coal. Sultzbach	64.4	83.55	5.17	11.48	8603	8024	....	.....
Gruner's Class 2. Long-flaming, caking or gas coals	60-68	80-85	5.8-5	14.2-10	8500-8800	. . .	4864-5312	58.8
Long-flaming, caking coal. Duttweiler	63.5	83.82	4.60	11.58	8724	7858	....	......
Long-flaming, dry coal. Montceau	60.6	78.58	5.23	16.19	8325	7455	....	......
Very long flaming coal. Von der Heydt	60.4	81.56	4.98	13.46	8462	7727	....	.. ..
Long-flaming, dry coal. Louisenthal	59.0	76.87	4.68	18.45	8215	7032	....	......
Long-flaming, semi-coking coal. Friedrichstall	58.5	78.97	4.67	16.36	8457	7287	....	......
Gruner's Class 1. Long-flaming, dry coals	50-60	72-80	5.5-4.5	19.5-15	8000-8500	. . .	4288-4800	55.1
Highly bituminous lignite, Bohemia	55.0	76.58	8.27	15.15	7924	8387	....	.. ..
Dry lignite, Rocherbleu	52.0	72.98	4.04	22.98	6480	6300	....	......
Bituminous wood	51.4	67.60	4.55	27.85	6311	5831	....	......
Fossil wood, passing into lignite	50.4	66.51	4.72	28.77	6358	5760	....	.. ..
Fat lignite, Manosque	48.8	70.57	5.44	23.99	7363	6542	....	......
Dry lignite, Manosque	46.8	66.31	4.85	28.84	7006	5788	....	......
Cellulose, $C_{12}H_{10}O_{10}$	28-30	44.44	6.17	49.39	3622	3590	....	......

* The nitrogen rarely exceeds 1%.

TABLE III.—JOHNSON'S RESULTS CORRECTED AND COMPARED BY PER CENT OF FIXED CARBON TO TOTAL COMBUSTIBLE.

No. of Coal.	Order of Excellence.	Name of Coal.	Evaporation per lb. Combustible.*	Fixed C. % total C. and vol. matter.	Vol. mat., % total C. and vol. matter.	Evap.‡ Equivalent, Calories.
		ANTHRACITES, PENNSYLVANIA.				
1	15	Beaver Meadow slope No. 3	11.15	97.4	2.6	5988
2	14	" " " No. 5	11.29	97.2	2.8	6063
3	9	Forest Improvement	11.52	95.6	4.4	6186
4	8	Peach Mountain	11.59	96.8	3.2	6224
5	23	Lehigh	10.26	94.4	5.6	5509
6	11	Lackawanna	11.47	95.7	4.3	6159
7	10	Lykens Valley	11.50	92.4	7.6	6176
		SEMI-BITUMINOUS.				
8	3	N. Y. & Maryland Mining Co., Md	11.95	85.6	14.4	6417
9	13	Neff's Cumberland, Md	11.30	85.5	14.5	6068
10	7	Easby's, Md	11.66	83.6	16.4	6261
11	1	Atkinson & Templeman, Md	12.39	83.2	16.8	6653
12	5	Easby & Smith's, Md	11.76	82.7	17.3	6315
13	4	Dauphin & Susquehanna, Pa	11.91	84.3	15.7	6396
14	6	Blossburg, Pa	11.68	83.2	16.8	6272
15	12	Lycoming Creek, Pa.	11.43	83.8	16.2	6138
16	2	Quin's Run, Pa	12.02	80.1	19.9	6455
17	20	Karthaus, Pa	10.54	79.1	20.9	5660
18	16	Cambria Co., Pa	10.91	77.2	22.8	5859
		BITUMINOUS, UNITED STATES.				
19	17	Barr's Deep Run, Va	10.81	77.5	22.5	5805
20	21	Crouch & Snead, Va	10.38	71.1	28.9	5574
21	18	Midlothian (screened), Va	10.63	60.9	39.1	5708
22	19	Chesterfield Mining Co., Va	10.55	64.3	35.7	5665
23	28	Tippecanoe, Va	9.15	61.3	38.7	4914
24	24	Creek Co., Va	9.82	65.0	35.0	5273
25	27	Clover Hill, Va	9.15	63.8	36.2	4914
26	26	Pittsburg, Pa	9.54	59.9	40.1	5123
27	31	Cannelton, Ind	8.24	63.2	36.8	4425
		BITUMINOUS, FOREIGN.				
28	22	Pictou, N. S	10.35	67.2	32.8	5558
29	29	Sidney, N. S	9.06	73.9	26.1	4865
30	30	Liverpool, Eng	8.80	57.8	42.2	4726
31	25	Newcastle, Eng	9.78	61.4	38.6	5252
32	32	Scotch, Scotland	8.23	54.9	45.1	4419
33	33	Dry Pine Wood	5.02	....	....	2696

* Evaporation from and at 212° F. per lb. combustible. Johnson's figures corrected by multiplying by 1.066

An inspection of the diagram reveals several interesting facts.

1. Mahler's results group themselves very closely around the average curve of the diagram, indicating therefore that there is a law of relation between the composition of the coal as determined by proximate analysis and the heating value, as well as between the elementary composition and the heating value. Knowing, therefore, the percentage of fixed carbon in the dry coal free from ash, we may in the case of all coals containing over 58% of fixed carbon predict their heating value within a limit of error of about 3%.

2. This close grouping of the several tests about an average curve indicates great uniformity of action of the calorimetric apparatus, and a high probability of its accuracy, unless there is a constant or a uniformly proportional error, which is not probable to any important extent.

3. Mahler's results are regularly lower than those of Scheurer-Kestner for coals of similar composition, and more closely approximate the theoretical heating power, as determined by Dulong's formula ; indicating that Scheurer-Kestner's apparatus and results were not as accurate as those of Mahler, and that Scheurer-Kestner's observation that the heating power of coals is generally greater than that determined from their composition is not true to the extent believed by

Scheurer-Kestner, especially in the case of coals containing over 70% of fixed carbon.

4. From the average curve through Mahler's results the following table may be constructed :

APPROXIMATE HEATING VALUE OF COALS.

Percentage of Fixed Carbon in Coal Dry and Free from Ash.	Heating Value.		Percentage of Fixed Carbon in Coal Dry and Free from Ash.	Heating Value.	
	Calories.	British Thermal Units.		Calories.	British Thermal Units.
97	8,200	14,760	63	8,400	15,120
94	8,400	15,120	60	8,100	14,580
90	8,600	15,480	57	7,800	14,040
87	8,700	15,660	54	7,400	13,320
80	8,800	15,840	51	7,000	12,600
72	8,700	15,660	50	6,800	12,240
68	8,600	15,480			

Below 50% of fixed carbon the law apparently does not hold, as is shown by the tests of some of the lignites, which depart considerably from the average curve. The cannel coal and the turf from Bohemia, tested by Mahler, lie far above the average curve. In the case of the cannel coal this may be accounted for by the relatively high percentage of hydrogen and low percentage of oxygen, but it is difficult to account for the high value shown by the turf.

5. The comparison of the industrial or steaming power by Johnson's and Gruner's tests with the heating value as determined by a calorimeter strongly emphasizes the fact that in the burning of highly bituminous coals under ordinary steam-boilers a greater percentage of heat is lost than in the burning of anthracite and semi-bituminous coals. There is but little difference in the calorimetric heating power of coals containing respectively 70% and 85% of fixed carbon, but in industrial practice the latter give from 15% to 20% higher results. This is simply due to the great difficulty in ordinary boiler furnaces of burning the excess of volatile combustible matter which passes out of the chimney in smoke and unburned gases.

It is greatly to be desired that tests similar to those made by Scheurer-Kestner, Mahler, and others on European coals should be made on the coals of the United States. The calorimetric apparatus used by Mahler is all that can be desired for determining total heating value. If our Western coals, which are now being wasted in steam-boiler furnaces to the extent of many millions of dollars per year, could be tested calorimetrically by this apparatus, and the results compared with those of actual boiler tests, we should then realize the enormous extent of the waste that is taking place, and inventors would be encouraged to devise improved boiler-furnaces by the use of which a large percentage of the coal now wasted might be saved.

COPPER.

The production of copper in the United States has increased each year, almost without an exception, since the commencement of the industry, and in recent years at a rate which has brought it not only above that of any other country, but has made it equal in amount to the aggregate product of all the rest of the world. It is not surprising that the copper markets of Europe should look with amazement, the copper mines of the world with anxious forebodings, and the mining and metallurgical professions with unbounded admiration at this marvelous growth, and perhaps still more at the figures of cost which, despite high wages, high values of supplies, and transportation for thousands of miles to the nearest seaport, have enabled us to control the markets of the world and have almost placed upon the ragged edge of bankruptcy the copper mines of the older producing countries. It is not unnatural that those who have watched from a critical position the rising tide of this great stream, and the ever increasing flow from the sources which supply it, should have feared a coming "deluge" of the metal. They overlooked, however, the facts that though the volume of the torrent easily carried away all artificial dams and obstructions in its course, and drowned out the little surface springs along its route, it spread its fertilizing flood over the desert and created such new uses and rapidly increasing demands that even its vast and growing volume could scarcely supply. The known sources are not inexhaustible; the stream may, yes, it will increase, but the area its very abundant floods have fertilized already absorbs the whole and calls for more. There can be no deluge now or hereafter, but there may be a drought and a famine.

The history of the growth of the copper industry from its commencement, in 1845, is outlined in the accompanying tables of production. The native copper ores of Michigan quickly attracted attention and became, by reason of the simplicity of the metallurgical operations required in rendering their contents marketable, the chief source of our supply of the metal, for many years furnishing from 70 to 90% of the total. A single mine, the Calumet and Hecla, for a quarter of a century has produced more than half of the Michigan output.

In the accompanying tables we have carefully revised the figures of production of the several Michigan mines, having found many clerical and other errors in them as usually published, and as the most authoritative statements of production, values, and costs we have taken the reports of the treasurers of the several com-

panies to their stockholders. Since 1882 we have credited the production to the several States and Territories where the ore was chiefly mined, and for recent years have given the output of each important mine or works in Arizona and Montana, thus adding very greatly to the interest of these reports and furnishing a guarantee and means of verifying their accuracy. It is not possible, however, to reach absolute accuracy in this distribution to States; for ores smelted in one State are produced in another, and some of the copper comes from ores marketed and smelted as lead or silver ores, but for all practical purposes it may be accepted as substantially accurate—every care has been taken to render it so. The statistics for recent years are from reports received by the *Engineering and Mining Journal* from all the producers in the country. In the report for the year 1891, published Jan. 2, 1892, there was a somewhat important error in the output of the Calumet and Hecla mine, which, as then stated, declined, and still declines, to give its output. We subsequently obtained the official statement of that company's product in 1891, and have also ascertained, though unofficially, its output in 1892. The figures published in the *Engineering and Mining Journal* at the beginning of each year were necessarily estimated by each producer as to his outturn in December, but each has revised and checked his figures, and as here published they may be considered final.

PRODUCTION OF COPPER IN THE UNITED STATES FROM 1845 TO 1881.

Year.	Long Tons.		Year.	Long Tons.		Year.	Long Tons.		Year.	Long Tons.	
	Total Production.	Michigan.		Total Production.	Michigan.		Total Production.	Michigan.		Total Production.	Michigan.
1846	150	26	1855...	3,000	2,648	1864...	8,000	5,476	1873...	15,500	13,378
1847	300	213	1856...	4,000	3,668	1865...	8,500	6,524	1874...	17,500	15,370
1848......	500	461	1857...	4,800	4,277	1866...	8,900	6,176	1875...	18,000	16,026
1849......	700	672	1858...	5,500	4,031	1867...	10,000	7,950	1876...	19,000	17,023
1850......	650	572	1859...	6,300	4,021	1868...	11,600	9,090	1877...	21,000	17,340
1851......	900	779	1860...	7,200	5,492	1869...	12,500	11,989	1878...	21,500	18,527
1852......	1,100	792	1861...	7,500	6,664	1870...	12,600	10,844	1879...	23,000	19,121
1853......	2,000	1,297	1862...	9,000	6,162	1871...	13,000	12,398	1880...	27,000	22,551
1854......	2,250	1,819	1863 ..	8,500	5.822	1872...	12,500	10,978	1881...	32,000	24.312

In 1845 the total production in the United States is estimated at 100 long tons, of which Michigan produced 12 tons.

Arizona.—The great mines of Arizona are, with a few exceptions, controlled by a single interest, and this is noted for its conservative and business-like policy. Having an abiding faith in the vastness of the future demand for copper, and an equally clear appreciation of the fact that all high-grade ores are limited in depth and that it is unwise to work out valuable property when prices for the product are so low as to leave no profit, they have reduced the output of their mines during the past year. Buffalo, which a year ago, as an independent producer, was making a large outturn, has been idle during 1892. Queen and Detroit have also a lessened output. Old Dominion has increased slightly, and is still working high-grade ores and making copper at a remarkably low cost. United Verde has also increased its product, but is not at present aiming at a very great product. The output of Detroit fell off 1,700,000 lbs. from its record in 1891, and though capable of increasing largely and rapidly, it is not likely to show any marked change during 1893 should the present "understanding" in the copper trade be maintained.

COPPER PRODUCTION IN THE UNITED STATES, IN POUNDS OF FINE COPPER.

	1882.		1883.		1884.		1885.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	17,984,000	8,029	23,874,000	10,658	26,734,000	11,935	22,706,366	10.137
California	827,000	369	1,601,000	715	876,000	391	469,000	209
Colorado	1,494,000	667	1,153,000	515	2,013,000	899	1,146,000	512
Michigan	57,131,000	25,505	59,257,000	26,454	69,328,000	30,950	72,759,000	32,482
Montana	9.058,000	4,043	24,664,000	11,010	43,093,000	19,238	67,797,864	30,266
New Mexico	369,000	388	824,000	368	59,000	27	80,000	36
Utah	606,000	270	342,000	153	266,000	118	126,000	57
Eastern and Southern States	1,955,000	873	1,007,000	449	1,222,000	545	252,000	113
All others	870,000	388	2,358,000	1,053	1,330,000	594	1,150,000	513
Total domestic production	90,794,000	40,533	115,080,000	51,375	144,921,000	64,697	166,486,230	74,324
From foreign ores	1,473,109	658	1,625,742	726	3,228,966	1,442	3,607,952	1,610
Total production	92,267,109	41,191	116,705,742	52,101	148,149,966	66.138	170,094,182	75,934
Stock, Jan. 1	....	....	....	....	30,000,000	13,394	30,000,000	13,394
Imports of bars, ingots, & old	531,000	237	632,039	282	195,378	86	574,514	256
Total supply	92,798,109	41,428	117,337,781	52,383	178,345,344	79,618	200,668,696	89,584
Deduct exports*	6,245,363	2,788	50,691,487	22,630	105,830,439	47,245	114,163,112	50,966
" consumption	....	....	36,646,294	16,359	42,514,905	18,979	51,505,584	22,993
Stock, Dec. 31	....	....	30.000.000	13,394	30,000,000	13,394	35.000.000	15.625

States.	1886.		1887.		1888.		1889.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	16,000,000	7,147	17,790,000	7,944	33,200,000	14,821	32,933,000	14,703
California	430,000	192	1,600,000	714	1,570,000	700	1,700,000	759
Colorado	409,000	182	2,012,000	898	1,621,000	724	3,100,000	1,384
Michigan	80,260,000	35,830	75,792,000	33,836	86,503,000	38,617	87,414,000	39,024
Montana	57,611,485	25,718	78,700,000	35,134	98.504,000	43,977	104,589,000	46,691
New Mexico	558,000	248	284,000	126	1,631,000	728	3,686,000	1,645
Utah	500,000	223	2,500,000	1,116	2,131,000	952	2,400,000	1,073
Eastern and Southern States	346,000	154	200.000	90	100,000	45	90,000	40
All others	1,332,000	594	2,433,000	1,086	3,241,000	1,446	3,625,000	1,618
Total domestic production	157,446,485	70,288	181,311,000	80,944	228,501,000	102,009	239,539,000	106,936
From foreign ores	4,795,050	2,140	3,935,000	1,756	5,218,000	2,329	5,190,000	2,317
Total production	162,241,535	72,428	185,246,000	82,700	233,729,000	104,338	244,729,000	109,253
Stock, Jan. 1	35,000,000	15,625	40,000.000	17,857	40,000,000	17,857	75,000,000	33,482
Imports of bars, ingots, & old	531,789	238	212,539	94	107,946	48	122,998	55
Total supply	197,773,324	88,291	225,458,539	100,651	273,826.946	122,243	319,851,998	142,790
Deduct exports*	66,315,661	29,605	43,000,000	19,196	80,000,000	35,714	73,000,000	32,589
" consumption	91,457,663	40,918	142,458,539	63,598	118,826,000	53,047	181,851,998	81,184
Stock, Dec. 31	40,000,000	17,768	40,000.000	17,857	75,000,000	33,482	65,000,000	29,017

States.	1890.		1891.		1892.		1893.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	36.977,192	16,508	41.894,699	18,703	38,383,116	17,135	43,773,675	19,542
California	1,600,000	714	3,750,000	1,673	3,200,000	1,430	2,825,773	1,261
Colorado	6.000,000	2,678	7,000,000	3,125	7,250,000	3,236	7,121,257	3,179
Michigan	100,695,000	44.953	114,400,000	51,071	108,170,000	48,290	113,462,119	50,653
Montana	110,955,733	49,534	112,359,839	50,161	161,051,477	71,898	154,706,859	69,066
New Mexico	870,000	388	1,600,000	714	500,000	223	273,515	123
Utah	600,000	273	1,700,000	759	2,000,000	893	1,312.171	585
Eastern and Southern States	4,200,000	1,875	1,300,000	580	1,300,000	580	415,025	185
All others	....	....	3,450,000	1,540	1,201,840	536	3,365,494	1,502
Total domestic production.	261,897.925	116,923	287,454,538	128,326	323,056,433	144.221	327,255.788	146,096
From foreign ores	6,017,000	2,686	11,500,000	5,185	10,200,000	4,553	7,723,387	3,448
Total smelted	267,914.925	119,609	298,954,538	133,511	333,256,433	148,774	334,979,175	149,544
Stock, Jan. 1	65,000,000	29,018	101,000,000	45,089	76,000.000	33,929	56,000,000	25,000
Imports of bars, ingots, & old	668,676	296	4.174,057	1,408	1,552,515	693	5,536,690	2,472
Total supply	333,583,601	148,923	404,128,595	180.008	410,808,948	183,396	396,515,865	177,016
Deduct exports*	40.000,000	17,857	115,122,067	51,394	90,036,800	40,198	180,066,880	80,387
" consumption	192,583,601	85,977	213,006.528	94,685	264,772,148	118,201	158,208,985	70,629
Stock, Dec. 31	101,000.000	45,089	76,000,000	33.929	56,000,000	25,000	58,240,000	26,000

* Exports are calculated from official reports of exports, counting "ore" as averaging 55% copper in 1887 to 1890, inclusive, since that date the actual contents is given.

COPPER PRODUCTION OF ARIZONA.
(Pounds of fine copper.)

Name of Mine.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
Arizona Copper	6,832,880	5,250,000	5,714,000	7,133,188	7,600,000	4,662,281	5,910,044	6,061,054
Buffalo	....	....	....	....	....	398,849	2,302,765	....
Commercial Mining Co.	....	....	....	....	....	....	....	279,451
Copper Queen	6,721,535	3,800,000	5,945,550	9,379,949	9,408,000	9,031.680	10,203,683	9,806.764
Detroit	3,456,000	2,135,000	4,404,321	5,420,004	5,076,890	4,777,814	4.194,672	2.878,593
Halbrook & Cave	....	....	....	3,042,468	2,561,144	2,925,418	2.751,445	3,023,605
Old Dominion	4,688,640	4,567,665	1,441,770	4,870,000	5,923,289	7,491.606	6.982,306	7,666,274
United Verde	....	....	272,124	3,200,000	1,923,738	5,475,573	6,946,956	8,284,259
Other mines	1,047.311	247,335	12,235	154,391	439,939	136,779	408,129	
Total pounds	22,706,366	16,000,000	17,790,000	33,200,000	32,933.000	34,900,000	39,700,000	38,000,000
Long tons	10,137	7,143	7,942	14,821	14,703	15,581	17.723	16,964
Metric tons	10,295	7,214	8,072	15.064	14,942	15,835	18.003	17,241

California.—As a copper producer California has declined during the past year, owing to a fire at its principal mine toward the close of 1891. The State produced 3,200,000 lbs. of copper and promises an increase, and in time may even become an important producer. Some of its copper went into consumption in the manufacture of paint.

Colorado.—While Colorado does not possess a single large copper mine, its output of the metal is important and increasing. Most of its copper comes from the treatment of copper-bearing silver and lead ores, which are reduced in the lead furnaces and the resulting copper mattes shipped chiefly to Eastern refiners. The Leadville ores as they attain depth are becoming richer in copper (though, as a rule, poorer in other metals), and are adding to the importance of the State as a copper producer. It is very difficult to ascertain with accuracy the actual source of all the copper produced by the smelters in Colorado, but from a careful analysis of the reports made to the *Engineering and Mining Journal* it appears that there has been produced in the State 7,250,000 lbs. of the metal. This copper has not, however, all gone into use as "bars," "pigs," "ingots," or even as matte, but a quite important amount has been used in the manufacture of copper sulphate, and a small amount in paint.

Michigan.—The production of this State decreased during the year 1892, chiefly on account of the low price of the metal, which was unremunerative to several of the smaller mines, and because of the purposely reduced output of the Calumet and Hecla mine. There is no immediate prospect of any large increase from this district, though, if called upon to do so, its large mines could undoubtedly send out a much greater amount of the metal than they have yet done. While the deep explorations on these wonderful deposits of native copper, which have now attained a depth of 4000 ft. from the surface, show the copper contents to be well maintained, it is noteworthy, as pointed out a year ago in this annual review, that the quality of the metal, at least for electric purposes, is not quite up to its former high standard. The great reduction in the cost of electrolytic refining and the high quality of the product render the trade more independent of the heretofore unequaled "Lake" copper and widen the field from which high-quality metal can be drawn. Tamarack has not increased its output during 1892, but Quincy, which has probably greater immediate possibilities than any of the other Lake mines, is pushing ahead toward a very large production. Tamarack, Junior, enters the list as a producer and will increase largely during 1893; but no other mines made important developments in 1892, and some of

those from which much was expected have not realized the dreams of sanguine stock speculators.

Montana.—For the first time this State has taken the leading place as a copper producer, having bounded forward in a single year 51,100,000 lbs., or more than the entire output of Arizona, and nearly two thirds as much as the production of Michigan. This vast increase was due to the phenomenal output of the Anaconda Company during the first six months of the year, when it turned out no less than 63,000,000 lbs. of copper, and brought its total for the year up to 100,000,000 lbs. This great property, including what are commonly known as "The Chambers Syndicate Mines" as well as the Anaconda and St. Lawrence, has abundantly demonstrated its enormous capacity to produce copper; but, while its mines are by no means exhausted and have still a long life before them, every one knows that the rich ores found near the surface are replaced in depth, here as in other districts, by ores of a very much lower grade and which require a more expensive treatment. It is not to be expected, therefore, that the past record of increase, if indeed any increase at all, can be maintained in the future. Even the great reductions in cost of treatment per ton of ore which lower freight rates, cheaper fuel and supplies have rendered possible, and the greater value of the product (by its more complete treatment near the mines), will together scarcely offset the lower grade of the ore.

COPPER PRODUCTION IN MONTANA.

(Pounds of fine copper.)

Mine.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
Anaconda	36,000,000	33,267,864	57,000,000	63,245,473	61,647,000	64,046,812	46,500,000	100,000,000
Boston and Montana	7,500,000	2,000,000	1,500,000	18,278,667	26,425,228	26,942,298	26,507,929	30,386,595
Clarks Colusa	10,000,000	7,000,000	7,100,000	700,000				
Butte and Boston	....	....	......	....	1,103,125	5,485,434	18,392,054	10,641,209
Butte Reduction Works.	2,500,000	1,700,000	1,565,000	3,521,556	2,560,000	3,001,209	2,915,000	2,864,000
Colorado, S. & M	1,200,000	2,000,000	1,500,000	1,488,000	2,954,000	2,320,000	3,641,384	4,560,972
Parrott	9,809,000	10,000,000	10,000,000	10,750,000	9,500,000	9,000,000	14,108,382	12,438,782
All others	789,000	1,644,136	35,000	521,304	399,647	200,247	1,135,251	3,408,382
Total pounds	67,798,000	57,612,000	78,700,000	98,504,000	104,589,000	110,996,000	113,200,000	164,300,000
Long tons	30,267	25,769	35,134	43,975	46,690	49,552	50,536	73,348
Metric tons	30,761	26,139	35,708	44,693	47,454	50,361	51,361	74,546

The cost of production by this company is not accurately known, nor the recipts from the vast quantity of copper it has marketed. There is no record of the company having paid any dividends, and probably no one pretends that it has in its enormous plant and in some less tangible assets a fair equivalent for the exhaustion of so much of its magnificent and unrivaled ore body. Some idea of the extent of this plant may be formed from the following particulars: The mines which are in the vicinity of Butte, Mont., are worked down to the depth of more than 1000 ft. and have produced as much as 3000 tons in a day, and have averaged nearly this daily for a month. The ores are treated in two concentrating and two smelting works at Anaconda, Mont., which have a capacity exceeding 3000 tons a day, and are, in fact, the largest works in the world. These works have been remodeled many times as greater experience indicated improvements, or as new managers, with new ideas as to what was required, took charge of them.

For crushing ore 14 direct-acting steam stamps, similar to those so long in use at the copper mines of Michigan, are employed. An immense number of round bud-

LAKE SUPERIOR COPPER MINES.

Year.	Adventure.	Allouez.	Atlantic.	Aztec.	Calumet and Hecla.	Centennial.	Central.	Cliff.	Copper Falls	Conglomerate.	Evergreen Bluff.	Franklin.	Grand Portage.	Hilton (Ohio).	Huron.	International.	Isle Royale.
1855*	68,000	....	....	38,000	....	....	....	6,980,000	316,000	....	2,599	....	....	4,000	....	....	116,000
1855	62,034	....	....	3,467	....	....	83,836	1,874,197	200,000	....	14,100	....	....	....	6,000	....	186,000
1856	143,336	....	....	51,139	....	....	64,903	2,220,934	208,010	....	25,110	....	....	705	24,000	....	465,124
1857	233,941	....	....	29,361	....	....	53,875	2,360,850	307,305	....	46,942	6,699	....	....	70,000	....	420,117
1858	115,678	....	....	6,251	....	....	....	2,260,433	303,852	....	6,665	113,104	....	....	48,000	....	356,810
1859	198,431	....	....	18,493	....	....	241,622	1,415,007	346,174	....	38,811	233,211	....	....	45,387	3,903	416,056
1860	42,749	....	....	6,203	....	....	114,197	1,343,393	510,818	....	63,817	484,196	*100,000	....	9,000	....	338,198
1861	4,676	....	....	....	....	....	248,741	1,928,011	560,011	....	99,187	1,402,078	....	....	98,000	....	917,274
1862	22,089	....	....	....	....	....	484,764	2,004,960	458,299	....	119,257	1,466,645	....	....	139,305	....	896,139
1863	....	....	....	....	....	....	619,268	2,100,354	319,348	....	141,446	1,278,684	355,793	....	138,206	32,563	721,841
1864	1,755	....	....	....	....	....	901,292	1,351,334	358,808	58,700	....	1,211,335	489,104	11,179	101,745	22,069	582,386
1865	7,491	....	....	8,700	....	....	1,099,242	1,498,626	470,000	102,492	375,213	1,559,481	483,592	6,411	468,011	63,502	689,836
1866	4,439	....	13,475	32,000	....	....	1,333,036	1,642,928	1,137,169	....	....	1,638,994	....	5,767	....	69,823	617,336
1867	....	....	1,760	80,000	1,351,173	....	1,244,441	1,121,725	2,257,485	....	....	1,402,455	....	....	1,367,169	....	762,852
1868	....	....	1,528,258	72,000	5,098,375	....	1,800,943	1,227,746	479,384	....	....	1,467,476	159,282	....	1,480,080	....	295,033
1869	1,154	3,775	1,646,857	175,267	12,315,771	a 8,290	1,807,801	725,247	691,400	....	147,662	1,559,940	72,314	....	1,682,863	....	a150,672
1870	2,931	....	372,617	25,288	14,061,584	a426,366	1,327,156	444,381	772,990	....	111,420	1,178,000	....	3,345	a 84,183	8,630	....
1871	6,391	....	....	13,153	16,222,590	a743,288	1,432,662	142,238	478,883	....	45,048	700,000	....	....	a265,453	19,482	a181,217
1872	17,055	....	....	11,550	16,163,836	a384,242	1,244,349	118,386	520,861	163,161	....	372,000	....	....	a553,689	65,100	a250,164
1873	7,345	a21,163	863,366	....	18,848,265	a309,785	1,503,117	751,203	1,086,640	280,743	....	366,000	....	....	a547,883	100,845	a240,100
1874	4,165	a1,008,134	1,372,406	13,412	20,125,225	a 10,618	1,740,603	1,054,901	1,070,359	81,271	....	567,790	....	....	a251,005	7,535	a180,876
1875	30,470	a1,385,574	1,531,531	16,252	21,473,954	....	1,466,952	1,162,873	407,587	25,220	....	1,166,800	....	....	a 63,289	8,762	a 96,682
1876	40,784	a1,561,875	1,835,041	27,378	21,690,737	....	2,161,400	900,146	17,488	177,701	....	1,926,641	....	....	a 63,857	10,653	a 28,199
1877	64,609	a1,300,279	2,054,304	29,934	22,568,468	....	1,995,609	161,319	11,950	33,417	....	2,339,817	....	3,555	a 82,161	17,703	a 31,985
1878	54,115	1,131,146	2,043,863	23,392	25,251,128	....	1,891,053	414,415	11,790	280,345	71,873	2,599,528	34,124	6,807	65,100	1,488	31,933
1879	21,785	1,431,452	2,339,073	16,737	26,270,943	....	1,799,493	134,336	....	140,012	30,405	2,829,703	35,423	2,050	29,760	417	26,880
1880	2,951	1,318,471	2,341,145	5,757	31,675,239	....	2,026,078	78,962	6,615	233,814	10,651	2,236,466	77,860	....	70,285	....	77,469
1881	7,500	1,204,209	2,528,009	....	31,360,781	....	1,418,465	79,392	669,121	386,091	968	2,667,952	26,264	....	254,515	....	47,308
1882	429	1,683,557	2,634,675	3,129	32,053,528	82,554	1,353,597	66,053	587,500	734,249	....	3,264,120	757,080	....	364,579	5,625	35,447
1883	....	1,751,377	2,682,197	....	33,125,045	....	1,268,556	10,374	804,000	222,117	....	3,489,308	735,598	....	720,213	16,462	16,874
1884	4,333	1,932,174	3,163,585	....	40,474,585	....	1,446,747	28,255	891,168	1,198,691	955	3,748,652	....	....	1,927,660	178,351	30,164
1885	8,436	2,170,476	3,582,256	....	47,247,990	....	2,157,408	8,332	1,150,538	41,155	6,736	3,999,172	....	10,342	2,671,163	27,433	....
1886	985	1,725,463	3,503,670	....	50,518,220	....	2,512,886	22,342	1,396,679	44,505	1,006	4,264,297	....	19,135	1,996,695	7,488	....
1887	....	885,010	3,641,865	....	46,016,123	....	1,923,279	145	736,477	8,913	1,077	3,915,838	....	17,155	1,484,103	....	....
1888	....	314,198	3,974,972	....	50,295,721	....	1,817,023	....	1,160,000	....	26,888	3,655,751	....	14,961	2,375,147	....	....
1889	....	1,762,816	3,698,837	....	48,668,296	....	1,270,592	....	720,000	....	....	4,346,062	....	....	2,219,473	....	....
1890	15,485	1,409,828	3,619,972	....	59,868,706	....	1,413,397	....	660,000	....	....	5,638,112	....	....	1,736,777	....	....
1891	56,008	1,241,423	3,653,671	....	63,586,620	435,784	1,321,417	....	1,440,000	....	....	4,319,840	....	6,400	1,215,734	....	....
1892	....	546,530	3,703,875	....	57,925,000	....	1,562,867	....	1,400,000	....	....	3,767,000	....	....	460,000	....	....

* Previous to 1855.

(a) May 1st of following year.

LAKE SUPERIOR COPPER MINES—*Continued.*

Year	Kearsarge.	Knowlton.	Mass.	Minnesota.	National.	Ogima	Osceola.	Peninsula.	Pennsylvania. (Northwest.)	Pewabic.	Phœnix.	Quincy.	Ridge.	Sheldon.	St. Clair.	Tamarack.	Sundry.	Total.
1855*	...	...	...	3,020,000	157,477	...	...	...	1,110,000	...	38,000	...	60,000	...	...	...	2,421,651	14,331,727
1855	...	...	...	2,080,000	48,302	...	...	...	198,080	4,301	6,000	...	70,631	...	...	...	1,095,222	5,932,170
1856	...	...	...	3,490,714	176,483	...	...	...	3,348	107,667	16,000	13,462	73,874	...	...	...	1,131,583	8,216,392
1857	...	...	16,228	3,952,000	316,158	...	...	...	58,543	236,254	34,000	122,762	58,790	...	...	...	1,258,081	9,581,906
1858	...	...	12,000	3,802,914	264,804	...	...	...	166,100	416,603	...	306,772	78,690	...	...	...	771,439	9,030,115
1859	...	...	52,682	3,344,587	488,176	...	...	...	148,144	1,029,949	56,590	357,114	...	...	...	...	570,968	9,006,305
1860	...	...	...	2,680,500	1,078,609	...	...	...	242,097	1,917,426	40,062	1,940,414	...	100,000	...	...	789,859	12,301,538
1861	...	...	...	3,016,824	1,383,760	...	...	...	109,920	1,849,992	68,790	2,364,852	...	...	...	...	875,358	14,927,474
1862	...	22,439	...	2,520,000	865,752	...	...	7,982	...	1,571,281	63,590	2,306,218	...	...	...	...	854,387	13,803,100
1863	...	85,451	...	1,677,500	561,179	53,530	...	...	...	1,691,562	144,118	2,225,407	...	...	...	...	894,088	13,040,338
1864	...	...	9,452	1,446,000	628,516	50,000	...	7,000	163,960	1,429,857	284,187	2,498,574	16,917	...	...	...	1,001,220	12,625,390
1865	...	196,724	12,936	403,000	696,168	140,990	...	318,160	379,369	1,731,394	405,000	1,847,500	170,433	72,912	8,815	...	1,397,050	14,613,048
1866	...	...	10,112	391,500	647,371	277,310	...	163,906	128,090	1,346,140	410,000	2,114,220	142,411	133,497	62,200	...	1,511,512	13,833,236
1867	...	...	10,040	376,500	660,922	168,480	...	62,493	336,660	1,646,458	310,115	1,831,448	189,537	618,946	87,720	...	1,929,465	17,807,844
1868	...	...	18,939	230,900	619,820	199,360	...	234,536	...	1,043,523	260,000	1,461,000	172,000	333,118	136,665	...	2,052,070	20,370,508
1869	...	106,977	3,213	227,500	256,947	18,045	...	...	...	960,409	796,630	2,460,635	253,840	186,368	46,197	...	551,335	26,857,109
1870	...	...	3,408	401,500	260,660	...	...	...	...	546,000	999,000	2,572,980	245,400	...	...	...	442,392	24,290,231
1871	...	...	18,692	368,000	411,086	9,839	...	...	...	444,600	1,219,862	2,338,882	350,150	...	...	...	359,373	27,770,889
1872	...	17,559	1,903	252,000	336,770	...	...	...	...	467,000	728,470	2,296,308	257,920	...	18,072	...	350,604	24,590,999
1873	...	70,442	8,265	148,171	167,870	...	...	66,200	...	572,400	521,080	2,800,005	231,140	...	81,867	...	371,735	29,965.630
1874	...	6,215	11,925	186,338	142,052	...	936,000	...	...	294,607	1,398,400	3,046,698	374,113	...	5,400	...	540,058	34,430,106
1875	...	6,562	3,014	133,419	98,878	...	1,330,303	...	...	625,271	1,404,276	2,892,617	328,447	...	...	...	439,155	36,097,898
1876	...	...	81,952	88,954	166,647	...	1,693,737	6,015	...	568,995	1,396,530	2,949,863	290,018	...	...	...	446,361	38,130,972
1877	...	5,975	100,238	113,148	68,737	...	2,774,777	11,998	...	693,777	1,022,493	2,720,558	296,815	...	...	...	338,562	38,841,788
1878	...	8,629	412,339	175,027	22,736	2,800	2,705,998	1,746	...	522,826	301,172	2,991,950	251,837	1,622	...	...	189,889	41,500,671
1879	...	...	456,294	92,762	17,506	17,937	3,197,387	...	...	332,519	543,426	2,639,958	215,469	...	...	...	208,155	42,829,882
1880	...	...	517,159	32,033	...	5,885	3,381,061	...	...	970,509	436,010	3,696,263	223,353	46,931	13,195	...	131,649	49,615,811
1881	...	...	467,684	24,227	...	16,776	4,176,976	...	...	1,876,244	409,357	5,702,706	235,606	10,031	125,493	...	763,319	54,458,994
1882	...	...	737,440	10,672	17,060	4,207	4,179,782	...	...	1,482,666	537,177	5,682,663	102,936	3,299	87,126	...	659,651	57,130,801
1883	...	...	659,474	6,226	26,006	3,000	4,256,409	849,400	...	1,171,847	512,291	5,549,087	60,155	...	125,225	7,435	1,188,110	59,256,786
1884	...	21,368	562,718	1,144	87,368	1,106	4,247,630	1,225,981	...	231,543	621,004	5,680,087	74,030	9,828	139,407	...	1,399,262	69,327,796
1885	...	21,976	363,500	12,608	162,252	12,291	1,939,169	...	...	...	361,108	5,848,530	73,390	...	79,686	181,669	621,466	72,759,082
1886	...	*38,806*	*247,179*	...	184,706	...	3,560,786	131,556	...	...	101,804	5,923,519	158,272			3,646,517	253,316	80,259,832
1887	...	38,870	16,000	...	25,187	952	3,583,723	...	...	...	13,497	5,923,519	84,902			7,405,606	70,122	75,792.362
1888	829,185	...	70,944	...	...	...	4,134,320	...	...	...	...	6,367,809	50,890	Wolverine.	Tamarac Jr.	11,409,217	5,860	86,502.556
1889	1,918,849	...	...	...	470,301	...	4,534,127	736,507	...	...	...	6,405,686	31,969			10,605,451	25,000	87,413.966
1890	1,598.525	...	...	...	123,897	...	5,294,792	1,108,660	...	...	...	8,064,253	17,645			10,106,741	18,569	100,695,359
1891	1,727,390	7,120	30,114	...	103,888	...	6,543,358	1,509,670	...	...	...	10,542,519	43,049	312,112		16,161,312	61,197	114,328,218
1892	1,580,192	...	17,450	...	36,385	...	6,894,256	973,217	...	...	...	11,103,926	41,462	187,962	796,769	16,426,683	116,780	107,540,304

dles concentrate the fine ore, and the concentrates are roasted in 136 Brückner revolving cylinder furnaces and 50 calcining furnaces. Fifty-six matting furnaces put the material in the form of a 50% to 55% matte, some of which has been exported or has been sent to Baltimore, Md., for further treatment. Now, however, much of it goes to more than a dozen Bessemer or Manhés converters, the product from which goes to Baltimore for electrolytic treatment, and some of the matte is so treated in an experimental electrolytic plant at Anaconda.

The advantages which Baltimore possesses over Anaconda appear to outweigh the cost of transportation on the larger amount of material, and the present plans have led to a great increase in the capacity of the Baltimore works. Hereafter no matte is to be shipped to Europe, but American works will treat the entire product, and put the greater part of it in the form of electrolytic copper. This is a course which will in many ways be a great advantage.

The Parrott and especially the Butte and Boston companies reduced, while the Boston and Montana increased, their output during the year. The last mine now stands third in the list of great copper producers in this country, only the Anaconda and the Calumet and Hecla leading it.

Owing to the limited quantity of water and the high price of fuel at Butte, the Boston and Montana Company has established a magnificent ore dressing, smelting, bessemerizing, and electrolytic plant at Great Falls, Mont., where it has not only abundant water power, but very cheap coal. This new plant is undoubtedly the finest yet established in the copper industry of any country, and will mark a distinct advance in the same. The water power at Great Falls is estimated at a minimum of 12,000 horse-power, of which the Boston and Montana has one station developing about 2500 horse-power from seven horizontal Victor turbines —two with 44 in. wheels to drive the concentrating and smelting plants, two 22 in., two 20 in., and one with 40 in. wheels to drive a 48 × 48 in. blowing-engine to supply blast, at 17 lbs. pressure, to the Bessemer converters, a number of pumps both for the concentrators and for the hydraulic plant used at the furnaces and converters, and to drive also a Thomson-Houston dynamo for 650 incandescent and 50 arc lights, and a 30 kilowatt 500-volt machine for working a crane.

The concentrating plant is in a building 136 × 262 ft., heated with steam from boilers of 150 horse-power, and consists of two 10 × 20 in. rock-breakers, two screens, four 7 × 10 in. rock-breakers, and three sets of 15 × 26 in. rolls. The ore is concentrated in Collum jigs, the middlings recrushed in rolls, and the fines dressed on double buddles 16 ft. in diameter. The slimes go to Frue vanners.

The greatest novelty is found in the smelting plant, which has followed in many particulars the plans of a modern steel-mill. The smelter building, of iron, is 230 × 455 ft., is built on a side-hill to facilitate the transfer of material from one part to another, and is provided with ample pockets for ore, concentrates, and coal. A transfer truck worked by an electric motor takes railroad cars to any bin. The ore is roasted in 24 gas-fired Brückner cylinders, each 22 ft. long and capable of roasting a charge of 16 tons in 36 hours. These are arranged in sets of six and are charged from a traveling hopper provided for each group. The roasted ore runs into pockets, from which a transfer car takes it to the eight reverberatory smelting furnaces, which are on a lower level. These reverberators, with tilting hearths 16 × 13 ft., greatly resemble those in use in some of the Pennsyl-

vania steel works, and are heated with gas made in Taylor producers. The metal goes from the smelter into ladles, and then direct into the five-ton converters.

The electrolytic plant is not yet complete. Full descriptions of this most novel and interesting plant and of the work it does from time to time will be found in the *Engineering and Mining Journal*, where the current history of progress in every department of the mineral industry is given with a detail, working drawings, etc., which it would be impossible to include in this statistical work.

New Mexico has done but little in 1892, the Santa Fé mines being closed most of the year and having no adequate concentrating plant when they were running. No other mines came forward with any notable output. Nevertheless this territory may eventually become an important source of supply, for the existence of copper is known in many places, and developments may be expected to open some profitable deposits.

Utah.—As a copper producer Utah promises more than she performs. With promising deposits her output is still limited to about 2,000,000 lbs. a year—of which one mine turns out more than half; the remainder of the output comes from copper-bearing silver-lead ores.

Eastern and Southern States.—The former glory of the East has not yet returned, though the Ely or Copperfield mine in Vermont is opening up a fine body of ore and already produces 1,200,000 lbs. No doubt it will increase considerably in 1893, as will also the Elizabeth, the Bristol, and a few of the Eastern and Southern properties. The ores are all fair to low-grade pyrites, but the conditions for cheap mining, treatment, and marketing should long ago have secured their development on a much larger scale.

The foreign sources from which copper ores come to the United States for treatment are chiefly Canada, Spain, Venezuela, and Mexico, and during 1892 almost wholly from Canada and Spain. The Canadian and Rio Tinto ores are brought in large quantities as sulphur ores to be used in acid-making, and the copper is extracted by smelting from the roasted ore. It is only possible to import ores that come in free under the McKinley tariff, which excepts from duty the copper in ores containing less than 2% of the metal. It is highly probable that with free entry of ores and fuels a much larger metallurgical industry would grow up at our seaports, and by furnishing desirable fluxing material would at the same time stimulate the production of certain domestic ores that need such mixtures for economical treatment. The production of copper from foreign ores is given in the accompanying tables as a separate item in order to prevent duplications in arriving at the amount to be credited to each country in the world's production. From these tables it appears that the United States production from domestic ores in 1892 amounted to 145,170 tons of 2240 lbs., or about 49.8% of the entire world's output.

Imports and Exports.—The figures given in the accompanying tables have been compiled with great care. The amount of copper actually obtained from foreign ores during the year 1892 exceeded the amount given in the custom-house returns as imported, owing partly to the fact that the copper in low-grade ores does not appear in the custom-house returns, and also because stocks of ore on hand had been reduced during the year.

COPPER IMPORTS.*

Years.	Fine Copper in Ore.	Value.	Ingots, Old, etc.	Value.	Manufactures, Value.	Total Value.
	Pounds.	$	Pounds.	$	$	$
1864	†	†	†	†	†	†
1865	†	†	†	†	‡	†
1866	†	†	†	†	†	†
1867	†	936,271	2,205,685	369,761	140,320	1,446,352
1868	3,496,994	197,203	380,099	49,586	56,167	302,956
1869	24,960,604	448,487	303,992	36,962	69,545	554,994
1870	1,936,875	134,736	260,543	32,349	487,258	655,343
1871	411,315	42,453	373,449	46,222	676,510	765,185
1872	584,878	69,017	3,786,978	758,584	1,060,409	1,888,010
1873	702,006	80,132	12,587,194	2,524,376	971,682	3,576,190
1874	606,266	70,633	1,485,641	277,739	175,909	524,281
1875	1,337,104	161,903	478,949	69,504	59,843	291,250
1876	538,972	68,922	264,156	39,926	33,635	142,483
1877	76,637	9,756	263,029	34,034	41,987	85,777
1878	87,039	11,785	198,750	31,589	36,729	80,103
1879	51,959	6,199	126,157	13,456	44,539	64,194
1880	1,165,283	173,712	4,138,752	634,518	135,167	943,397
1881	1,077,217	124,477	1,178,196	152,587	289,263	566,327
1882	1,473,109	147,416	755,228	92,107	79,278	318,801
1883	†	203,948	632,039	69,225	381,713	654,886
1884	3,228,966	313,820	195,378	17,055	200,382	531.257
1885	3,607,952	356,274	574,514	43,617	94,702	494,593
1886	4,795,050	346,781	531,789	40,381	126,722	513,884
1887	3,935,432	199,696	212,539	15,086	107,100	321,882
1888	5,216,583	411,299	107,946	6,392	77,944	495,635
1889	5,190,252	311,277	122,998	11,041	92,762	495,080
1890	6,017,041	394,864	663,676	57,014	127,527	579.405
1891	11,690,312	875,855	3,154.557	276,263	513,611	1,665,729
1892	8,295,065	517,206	1,552,515	117,551	96,677	730,384

COPPER EXPORTS.*

Year.	Ore.‡	Value.	Pigs, Bars, Sheets, and Old.	Value.	Manufactures, Value.	Total Value.
	Pounds.	$	Pounds.	$	$	$
1864	12,273,072	181,298	102,831	43,229	208,043	432,570
1865	25,222,064	553,124	1,572,382	709,106	282,640	1,544,870
1866	24,088,960	792,450	123,444	33,553	110,208	936,211
1867	9,825,372	317,791	4,637,867§	303,048	171,062	791,901
1868	10,372,544	442,921	1,350,896	327,287	152,201	922,409
1869	13,598,816	237,424	1,134,360	233,932	121,342	592,698
1870	2,150,176§	537,505	2,214,658	385,815	118,926	1,042,246
1871	6,097,840§	727,213	581,650	133,020	55,198	915,431
1872	3,983,168	101,752	267,868	64,844	121,139	287,735
1873	5,068,224	170,365	38,958	10,423	78,288	259,076
1874	1,492,512	110,450	503,160	123,457	233,301	467,208
1875	5,746,160§	729,578	5,123,470	1,042,536	43,152	1,815,266
1876	1,714,048	84,471	14,304,160	3,098,305	343,544	3,526,410
1877	2,400,384	109,451	13,461,553	2,718,213	195,730	3,023,394
1878	3,690,064	169,020	11,297,876	2,102,455	217,446	2,488,921
1879	2,583,840	102,152	17,200,739	2,751,153	79,900	2,933,205
1880	2,421,776	55,763	4,206,258	667,242	126,213	849,218
1881	1,115,296	51,499	4,865,407	786,860	38,036	876,395
1882	2,904,832	89,515	3.340,531	565,295	93,646	748,456
1883	30,593,920	2,097,490	20,097,567	2,265,340	174,378	4,537,208
1884	75,425,280	4,366,910	30,405,159	3,888,759	112,505	8,368,174
1885	77,878,080	3,878,956	36,285,032	3,883,342	124,709	7,887,007
1886	46,762,240	2,341,164	19,553,421	1,968,772	76,386	4,386,322
1887	56,143,360	2,774,464	12,471,393	1,247,928	92,064	4,114,456
1888	89,035,520	6,779,294	31,706,527	4,906,805	211,141	11,897,240
1889	102,672,640	8,226,206	16,816,410	1,896,752	86,764	10,209,702
1890	54,116,160	4,413,067	10,971,899	1,365,379	139,949	5,918,395
1891	86,477,440	6,565,620	69,279,024‖	8,844,304	293,619	15,703,543
1892	113,108,800	6,479,758	30,515,736	3,438,048	245,064	10,162,870

* The imports and exports up to 1883 were compiled from Evans' *Government Statistics.* Since then from the *Annual Government Import and Export Statements.*

† Not stated.

‡ Ore, so called, is mostly matte, and during 1891 and 1892 matte exports averaged about 53% fine copper.

§ Evidently errors in quantities.

‖ Sheets are not included this year, but are reported with manufactures.

Fiscal years ending June 30, from 1864 to 1882, inclusive; 1883, eighteen months, ending Dec. 31; 1884 and subsequently, calendar years.

Since our custom-house does not record the amount of copper contained in ore, matte, etc., exported, these actual amounts have been ascertained directly from the shippers, and by comparisons with the returns of fine copper received in England, France, and Germany from the United States.

The Consumption of Copper in the United States in each year since 1883 is given in the preceding tables; it will be instructive to see how the consumption per head of population, commonly called the *per capita* consumption, has grown; for from this we can forecast the future demand for the metal. Such an immense increase in consumption—which now exceeds four pounds per capita per annum—is very remarkable. During the past year its use in electric conductors has been enormous, and is likely to continue. The make of electrolytic copper, which last year exceeded 50,000,000 lbs., and in 1893 will probably exceed 75,000,000 lbs., is due in great part to this demand. The increasing consumption of casting copper indicates the general growth of manufacturing, as well as the wealth of our people, which induces them to purchase articles of luxury and use made from copper or its alloys where formerly they used a cheaper material.

PER CAPITA CONSUMPTION OF COPPER IN THE UNITED STATES.

Year.	Population.	Consumption in Pounds.	Consumption Per Capita.
1850	23,191,876	13,420,000	0.550
1860	31,443,321	14,232,000	0.405
1870	38,558,371	24,684,000	0.603
1880	50,155,703	53,598,000	1.006
1890	62,600,000	190,541,676	3.043
1891	63,900,000	210,000,000	3.296
1892	65,100,000	266,895,715	4.075

Stocks of Copper on Hand.—We have received from each producer and refiner, with his statements of production, also a statement of his stocks of copper on hand, whether sold or unsold, and each has also courteously checked the figures of his stocks at the end of 1891. These confirm the totals for 1891 given in the annual statistical number of the *Engineering and Mining Journal*, Jan. 2, 1892. Stocks have been reduced in 1892. The Lake copper (exceeding 7,000,000 lbs.), which was held by bankers as a relic of the French syndicate, went into consumption, or was exported in 1892. There still remains from the old syndicate a lot of matte held in litigation.

In producers' hands stocks were unusually light at the close of 1892; in fact, there was scarcely any stock except what was in course of treatment, or on the way from the mines to the refineries or to market. 56,000,000 lbs., representing nearly 17% of the total year's production, or say two months' product, was the available stock. The market may be considered as practically bare when stocks, in all available marketable forms, do not exceed one sixth of the year's output, and they cannot fall much below that without causing a "famine" and sudden rise in price. The market is therefore at present in a very healthy condition statistically.

Copper Sulphate.—The production and consumption (for no large stocks are carried) of copper sulphate in 1892 has been reported by nearly all the important producers; but, in the absence of a few expected returns, we estimate a small portion of the output and place the whole at about 15,000,000 lbs., which consumed nearly 3,750,000 lbs. of copper.

THE WORLD'S PRODUCTION OF COPPER.†
(Compiled by Henry R. Merton & Co., London.)

Countries.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
Algiers	*500	*500	*600	*600	*600	260	250	110	150	50	160	120	120
Argentina	*300	*300	07	800	293	159	233	180	170	150	190	150	210
Australia	9,500	9,700	10,000	*11,000	*12,000	14.100	11,400	9,700	7,700	7,450	8,300	7,500	7,500
Austria	245	470	455	*455	*500	670	585	733	883	1,010	1,225	1,210	965
Bolivia	*2,000	*2,000	2,655	3,259	1,680	*1,500	*1,500	1,100	*1,300	1,450	*1,200	1,900	2,150
Canada	50	50	500	500	1,055	1,000	1,200	1,560	1,450	*2,250	2,500	3,050	3,500
Chile	49,318	42,916	37,989	42,909	41,099	41,648	38,500	35,025	29,150	31,240	24,250	26,120	19,875
Africa:													
Cape Colony	4,328	5,038	5,087	5,000	5,000	5,000	5,000	5,390	5,950	5,800	5,600	5,000	5,000
Namaqua	......	......	......	......	......	......	450	625	1,300	1,700	*2,100	1,450	900
England	3,462	3,662	3,875	3,464	2,620	3,350	2,733	1,471	389	1,456	905	935	*900
Germany:													
Mansfeld	8,400	9,800	10,999	11,516	12,643	12,582	12,450	12,595	13,025	13,380	15,506	15,800	14,250
Other	*600	1,000	1,743	*1,800	*2,000	*2,200	*2,800	*1,870	*1,850	*1,850	*1,850	*2,000	*2,000
Hungary	*900	820	815	660	790	600	*600	366	531	858	300	300	285
Italy	*1,140	*1,380	*1,480	*1,400	*1,600	*2,000	*2,000	2,100	2,500	3,500	*3,500	2,200	*2,200
Japan	*3,900	*3,900	*3,900	*4,800	*7,600	*10,000	*10,000	*12,000	*11,000	11,600	15,000	15,000	17,000
Mexico:													
Boleo	......	......	......	......	......	......	......	......	1,950	2,566	3,280	3,450	4,100
Other	*400	*400	333	401	489	291	375	250	100	200	500	875	1,025
Newfoundland:													
Betts Cove	*1,500	*1,500	1,718	1,500	1,053	668	778	1,125	1,180	1,300	1,115	735	540
Tilt Cove	......	......	......	......	......	......	......	......	125	750	1,500	1,000	1,500
Norway:													
Vigsnaes	2,000	2,040	2,350	2,300	2,340	2,390	2,180	1,920	1,150	1,020	1,007	925	615
Other	412	386	290	*290	322	392	380	330	275	300	435	*450	*450
Peru	*600	*600	615	440	395	362	229	75	50	250	275	150	280
Russia	3,300	3,300	3,700	4,000	4,400	4,700	5,100	4,875	5,000	4,700	4,070	4,800	4,800
Sweden	800	1,074	995	798	732	662	775	520	905	1,036	830	830	*830
Spain and Portugal	33,361	36,313	39,258	39,560	44,607	46,415	47,873	49,653	53,706	56,450	54,270	51,700	53,915
Rio Tinto	13,751	16,215	16,666	17,389	20,472	21,564	23,484	24,700	28,500	28,500	29,500	30,000	32,000
Tharsis	*11,324	*9,151	*10,203	*9,000	*9,800	*10,800	*11,500	*11,000	*11,000	*11,000	*11,000	*10,300	*10,500
Mason & Barry	*4,692	*6,603	*8,170	*8,000	*8,000	*7,500	*7,000	*7,000	*7,000	*7,000	*5,250	*5,600	*4,150
Sevilla	1,360	1,705	1,340	1,885	2,026	2,000	1,800	2,135	2,300	1,700	1,350	810	875
Portugueza	770	1,000	1,410	1,700	2,357	*2,300	1,665	1,258	*856	1,250	670	565	890
Other Mines	1,464	1,639	1,469	1,586	1,952	2,251	2,424	3,560	4,050	*7,000	*6,500	*4,425	*5,500
United States	23,350	25,010	30,882	40,470	51,570	64,700	74,050	69,805	79,109	101,710	105,774	116,325	124,179
Calumet and Hecla	11,720	14,150	13,995	14,300	14,750	18,050	21,075	22,550	20,550	22,450	21,700	26,250	25,000
Other Lake	7,410	8,050	10,355	11,140	11,900	12,875	11,135	13,040	12,780	16,200	17,069	18,200	22,505
Anaconda				4,045	11,010	10,265	16,070	14,850	25,450	28,225	27,500	28,600	20,750
Other Montana						8,990	14,200	10,870	9,775	15,478	19,018	20,960	29,786
Arizona	4,220	2,810	6,532	8,030	10,660	11,935	10,135	6,985	8,035	14,062	14,419	15,945	17,723
Other States				2,955	3,250	2,585	1,435	1,510	2,519	5,295	6,068	6,370	8,415
Venezuela:													
Quebrada	1,597	1,800	2,823	3,700	4,018	4,600	4,111	3,708	2,900	4,000	5,563	5,640	6,500
Total	151,963	153,959	163,369	181,622	199,406	220,249	225,592	217,086	223,798	258,026	261,205	269,615	275,589
Average Prices { Chile Bars / G. M. B.'s. }	£57 11s.	£63 1s. 3d.	£61 1s. 3d.	£67 0s. 6d.	£63 8s. 9d.	£54 15s. 6d.	£44 1s. 6d.	£40 6s.	£42 3s.	£82 7s. 6d. / £76	£49 10s. 6d.	£54 1s.	£51 3s.

* Estimated. † Fine copper, long tons (2240 lbs.).

THE WORLD'S COPPER PRODUCTION.

We have been favored with returns from most of the important foreign copper mines, and basing our estimates of certain small producers on the statistics of Messrs. Henry Merton & Co., we are enabled to give the following closely approximate estimate of the world's production of the metal in 1892:

1892.	Tons of 2240 lbs.	Metric Ton, 2204 lbs.
Australia:		
Wallaroo	5,200	5,285
Other mines	2,500	2,541
Canada	4,130	4,197
Cape:		
Cape Copper Company	5,350	5,437
Namaqua	1,378	1,405
Chile	20,000	20,326
England	1,000	1,016
Germany:		
Mansfeld	14,687	14,921
Other mines	2,000	2,032
Italy	2,000	2,032
Japan	18,000	18,288
Mexico:		
Boleo	6,183	6,284
Other mines	1.480	1,500
Newfoundland	1,900	1,930
Russia	5,000	5,080
Spain and Portugal:		
Rio Tinto	30,200	30,684
Tharsis	10,800	10,970
Mason & Barry	4,400	4,470
Sevilla	1,000	1,016
Other mines	200	203
United States	145,170	147,491
Venezuela	3,021	3,070
All other countries	5,875	5,960
Total	291,474	296,137

The table on the preceding page, compiled by Messrs. Henry Merton & Co. of London, gives the best estimate of the world's copper production from 1879 to 1891, inclusive.

FOREIGN COPPER PRODUCERS.

Canada.—The Canadian mines send nearly all their ore or matte to the United States for treatment. They may therefore be considered almost as "domestic producers."

The nickel-copper mines of Algoma produced 1729 tons (of 2240 lbs.) of copper during the year 1892, and are attracting great attention on account of the recent demand for nickel in the manufacture of steel. Whether this new use is to be extended or even to continue is not yet certain, for expert opinions still differ as to the absolute and relative virtues of this metal in steel. It appears to be pretty well determined, however, that in order to exercise its maximum efficiency it is necessary that the nickel added should be absolutely pure, and especially be free from copper—a separation that has thus far been somewhat difficult and expensive. These unwelcome shadows on the Algoma nickel properties have tended to restrict their development and output.

In Algoma and British Columbia a number of copper deposits, some of great magnitude, if current reports are to be credited, have been discovered, and when transportation becomes easier and cheaper they will, no doubt, be worked. As there are extensive coal-fields in both of these provinces, and natural gas and petroleum as well as copper ores in the Mackenzie Basin, Canada will some day become an important mineral-producing country. It is not, however, going to seriously affect the markets for copper in the next few years.

The mines of the Eastern Townships, Quebec, worked by the Nichols and the Eustis companies have continued large shipments to this country, and are in good condition to maintain and even to increase them. None of the small producers in this district has made a mark during the year. The output of Quebec was

57,641 short tons of ore, of which 53,415 tons were shipped. We place from direct returns the copper produced as 2200 tons.

Nova Scotia still declines to justify the statements and expectations of the many competent experts who have examined the Coxheath mines near Sydney Harbor. It appears that it is the moderate amount of capital required to build a few miles of railroad and to erect an efficient concentrating and smelting plant that is lacking, and not ore, as to the great amount and fair grade of which there seems to be no question. With unequaled conditions for cheap production, this district must some day be heard from as a copper producer of importance.

Newfoundland.—The great mines of copper pyrites of Tilt Cove and the Little Bay, which in the past have produced large amounts of copper, are approaching exhaustion and are not likely to maintain their output. New deposits may of course be discovered on that vast and little known island, but in the immediate future Newfoundland is likely to decline as a copper producer. Tilt Cove is still working, raising about 5000 tons of 4% ore a month.

Mexico.—The Boleo mine in Lower California is becoming an important producer, its output during the year amounting to no less than 6284 metric tons, as compared with 4172 metric tons in 1891. It is said the property is capable of increasing its output largely. The ores occur irregularly in several slightly inclined beds; only the richer portions, running 8 to 10%, are now worked. There is great difficulty in getting sufficient labor, the Indians, who do most of the work, being extremely unreliable.

Several other very promising copper deposits in Mexico have been talked of, some of them for years past, but lack of transportation and cheap fuel prevented their exploitation. Now that many new railroads are being built and the coal-fields of the country are attracting attention, and in some cases are being developed, there is every probability that Mexico will become more and more important as a copper producer. Should the United States high protective tariff on raw materials, such as ores of the metals, be removed, it is probable that some of the Mexican copper ores would come to our American smelters for treatment. Mexico is herself building up an important metallurgical industry, which is undoubtedly destined to increase, whether or not the United States tariff, which was chiefly instrumental in bringing it into existence, be removed.

Only about 100 tons of copper in copper ore are at present imported annually from Mexico. A certain amount comes in in silver-lead ores and finds its way to our refineries as lead smelter's matte. A larger amount of copper is sent to England in concentrates, and a smaller amount of ore is treated in Mexico and made into copper sulphate for use in the patio amalgamation of silver ores. Until some rich mine is discovered, or prices of the metal increase, the domestic copper industry of Mexico can scarcely get a start.

Venezuela.—The Quebrada mine has had its production greatly lessened during the year by political disturbances, and in October by exceptionally destructive floods and storms which caused great damage to the works and temporarily closed them. This fine property is capable of a large output and should be a natural tributary to American refineries. Thus far, however, but little of its product has come to American works, and none at all in 1892.

Spain continues to be the controlling influence in the foreign copper market and Rio Tinto the controlling influence in Spain—an influence it is likely to retain, as it owns the largest masses of ore in the long chain of deposits extending from near Seville across the Portuguese line to the Mason & Barry mines. The ore deposits in these slates have been known from time immemorial, and as their presence is indicated by heavy iron caps and the country is almost as bare and arid as our own West, there is little probability that any considerable quantity of ore has escaped detection. There are a number of small masses, some of them controlled by the larger companies, some of them worked as independent enterprises, but none of them at present large producers, or likely to be so in the future. Of the three most notable groups, those owned by Mason & Barry, by the Tharsis Company, and by the Rio Tinto Company, the first two are generally supposed to be approaching exhaustion, but the Tharsis Company is supplementing the copper produced from pyrites by smelting considerable quantities of a copper-bearing shale found in the neighborhood of its pyrites deposits. The Rio Tinto Company, besides drawing, as heretofore, from its great south vein, or ore mass, which is being worked by open cut, and from its San Dionysio ore mass, from which the ore is being extracted by galleries, has uncovered and recently commenced extracting ore from another very large ore mass known as the north vein, where it is said some 12,000,000 tons of ore are uncovered. Rio Tinto, therefore, has ample reserves and the facilities for utilizing them, but it has also a heavy debt to be paid; therefore it cannot be to the interest of the company to use up its reserves, vast as they may be, unless at a remunerative price. Besides pyritic mines there are large copper deposits in the Sierra Nevada, in the Province of Grenada, consisting of small veins of rich ore, which are not likely notably to swell the country's total product.

Outside of Spain the only large producer is Mansfeld in Germany. Operations were hampered last year by salt water which percolated into the mine from a salt lake between the Saale River and Eisleben, and within the area of the copper-bearing slates.

As the mine deepens, the lake waters filter into the workings in increasing quantity. This flow is now in excess of the pumping facilities. As a result the lower and richer levels are closed, and such of the furnaces as are running in two of the smaller establishments are in part fed by poor surface ores. The ultimate remedy, draining the Salziger Sea by cutting a canal to the Saale River, can be resorted to only after permission from the Government and the satisfaction of private claims. As operations to that end have not even been commenced, the output of copper from Mansfeld for the next few years will probably be below that of recent years.

Neither the Cape Copper Company nor the new Quebrada expresses an intention to augment its output, though there is no reason to suppose that operations are unprofitable at present figures.

In Newfoundland the Little Bay mine has ceased producing. In Chile we hear of no operations being initiated on an extensive scale to treat the low-grade ores, of which Chile's reserve now consists. At the present value of copper, those most conversant with Chile do not anticipate an increase of product, but, on the contrary, look for a slight and gradual decline. Whether this will be more than

compensated for by the product of Bolivia, now that the railroad is approaching the Coro-Coro district, remains to be seen.

Australia, with costly fuel and labor, shows a tendency to decline. We hear of large deposits of low-grade sulphurets being opened in Tasmania, but until they are actually produced, the promises of promoters cannot be accepted as facts.

The foreign field, therefore, presents us with no new discoveries actually developed, while it exhibits the old spectacle of some mines growing older and poorer, and of others meeting with obstacles which in one form or another invariably beset the extension of operations, especially in depth. On the other hand, the increase in railroad facilities in some parts of the United States, in Canada, in Mexico, in South America, in South Africa, in Australasia, and in fact throughout the New World, will undoubtedly stimulate the exploration for new mines and will render workable many promising deposits already known. There need be no fear that the supply of copper or of any other metal will become exhausted. All history has demonstrated that improved methods for finding, mining, and treating ores and for transporting materials have more than offset the exhaustion of great "bonanzas," and that the cost of production has, with slight fluctuations, tended steadily downward. This will probably be the future as it has been the past history of copper; though from the wonderfully rapid extension of the uses of the metal, especially for electrical purposes, and the depressing effect of the low prices of recent years on the development of new sources of supply, it seems probable that the market price of copper will be maintained and possibly advanced during the year 1893.

The products of the Tuscan copper mines are chiefly melted, refined, and rolled at the works of the Societa Metallurgica Italiana at Leghorn. The rolling-mill is admirably designed for economical work, and the furnaces are all heated by gas on the Radot system, by which they claim great economy of fuel over their previous practice.

The crude ore of 10% mixed with a small quantity of roasted lump ore, as it comes from the mines, is run down into a 30% or 35% copper matte, and tapped direct from the well of the furnaces into a trough-shaped Bessemer converter. Air is blown through this for twenty minutes or half an hour, the effect of which is to oxidize a little of the sulphur and all of the iron, which is converted into a slag at the expense of the silicious lining of the converter. The slag is so fluid that on tilting the converter most of it flows off. What remains is skimmed into a slag buggy, leaving in the converter an almost pure sulphide of copper. The converter is then returned to position and the blast turned on. In about half an hour the sulphur is eliminated as sulphurous acid and the copper reduced to 97% metal. The whole operation occupies a little over an hour. With a little patching, the lining lasts for seven charges. While one converter is in blast another is being relined, and the lining of a third is being dried.

The converters in use there produce at each blow about half a ton of 97% copper, and therefore are so light that they can be tilted by hand. The capacity of the small plant is five tons of copper per day.

The Copper Market in 1892.

The agreement made by the principal producers of the world to limit production was the important event of the year. This arrangement included the larger British companies, the Mansfeld Company, and the larger producers of this country. The Lake companies (although precluded by the laws of Michigan from entering into any agreement to curtail production) co-operate in furnishing statistics and information, which are submitted monthly to the producers on both sides of the Atlantic, with a view of diminishing, as far as possible, the fluctuations in business which are too often the fruit of false information. The negotiations leading up to this consummation dragged along for a considerable length of time, as an understanding between the different interests involved was difficult to arrange, but was finally concluded, and so far has worked very well indeed. It came into force on the 1st of July, and allowed the American producers a yearly output of 140,000 tons of 2240 lbs. each, they in turn being understood to export not more than 40,000 tons. The production and the exports during the last six months have, in fact, been below the figure allowed. This arrangement or understanding—for, so far as the American producers go, it does not amount to a formal or binding agreement—is very different in its aims and operation from the French syndicate of some years ago. While it is based upon the promises of a small number of the large producers of copper that their output will be kept within certain limits—apparently a point above their possible average working capacity—and that the exports from this country shall not exceed 40,000 gross tons,—which is all we could possibly do,—it in no respect attempts to limit the output of the small producers or to fix a price for the product of any. What, then, was the object and what has been the outcome of an arrangement to abstain from doing that which is beyond any one's power to do? To one unfamiliar with the trade such an arrangement would appear to be simply ridiculous, yet it has had an important effect upon the market.

From the erratic policy of a few of the large copper producers in forcing the output of their mines, and in selling their copper in a manner that was surprising and inexplicable to the more experienced and prudent men in the trade, the impression gained firm footing abroad that these, if not other American mines, were possessed of "unlimited quantities" of rich ores, and could, and, apparently from their anxiety to dispose of it, might, at any moment bring down on Europe a veritable "deluge of copper." The European traders took full advantage of this carefully nursed specter, depressed the prices when our unskillful sellers threatened them with a deluge, and put them up when the shower was over.

To the expert here it was evident from the beginning that the popular estimates of the quantities of copper in the mines were wildly inaccurate, for all experience demonstrated the rapid impoverishment of these high-grade ores in depth. It was also clear that the greatest extravagance in the erection of plants could not possibly continue the increase nor render permanent the large output that was being made by certain mines under the stimulus of domestic if not personal rivalry, intensified perhaps by a desire to impress the financiers of Europe

with an exalted opinion of the value of our unrivaled and "inexhaustible" sources of copper supply.

The actual average cost of producing copper by our large mines was very inadequately appreciated, if indeed it was fully known, even by those most interested. The *Engineering and Mining Journal* has sought to dispel the illusions on this point, and on another page of this work we add a further important contribution to the subject in a careful analysis of the accounts of some of the copper companies.

It was natural that a clearer appreciation of the actual cost of production, of the effects of the unskillful manner pursued in marketing the product, and of the rapidly declining grade of the ore should induce a more conciliatory frame of mind in some of the kings of the copper trade. Interchanges of experience and the unveiling of unfounded apprehensions cleared the air, and made evident that what had been thundered forth as an impending "deluge" was in fact only a sharp summer shower, that might indeed, if continued, submerge the earth, but that all experience proved could not last long. The mists are being dissipated, and there is a better understanding of the cost of copper, of what to avoid in marketing it, and of the extreme uncertainty and fleeting existence of "inexhaustible quantities" of high-grade ores in a mine. Our copper kings "know each other better since the clouds have rolled away," and the copper markets of the world are the gainers. There will be no deluge of 12-cent copper, though there will be no famine of the metal at 14c. per lb. That the effect of this arrangement on prices in general was not felt earlier was principally due, first, to the unsettled state of business in Europe, and then to the adverse influence of the constantly declining price of silver. Besides, prior to July 1 some of the mines were strained to the utmost limit to enable the companies to have large stocks from which to draw if the agreement should have an immediately favorable effect on prices.

Consumption in this country has been enormous,—especially for electrolytic purposes, a use which promises a great development,—and visible supplies have decreased. Of late the European statistics have also shown a decline; and as shipments from the United States must hereafter be light, and the European mines are restricting the output to even a greater average extent than the agreed upon five per cent on the output of 1891, there is every prospect that the year 1893 will see a brisk copper market and higher prices than ruled during 1892—a prospect full of comfort to the more or less patient stockholders of the majority of our copper mines, who have frequently seen their properties worked without any fair return on the capital invested; for, with the exception of some of the best of the Lake mines, few copper properties in this country have been very profitable.

It affords us great satisfaction to be able to record the fact that at last English smelters can no longer buy American furnace material on Cornish weights and assays; and this end would have been attained long since had it not been that the larger producers in this couutry, particularly those in Montana, continually gave way and submitted to the English mode of sampling. The Anaconda has now given notice to the English buyers that it will sell only on American weights and assays, and we are informed that the larger exporters have already received instructions from their foreign connections to buy for them on these

terms. Of course, with the exception of the small variations naturally shown by irregular material, the American and English sampling should be the same; but this has not been found to be the case, as the Cornish assay for copper does not show what is contained in the material, but what the assayer thinks the smelter can get out of it. Naturally this is against the interests both of fairness and of the sellers, who have had to make allowances that were not justified. Had this course been adopted several years ago, the Englishmen would have encountered fewer difficulties in trying to obtain supplies of furnace material; but the losses have been so heavy, and the sellers here have found it so utterly impossible to get account-sales rendered on what they rightly considered fair terms, that they determined to treat the copper here, and the Englishmen who so stubbornly opposed the introduction of a new and just system will henceforth find that they cannot procure material on the conditions that sellers would willingly have acceded to in the past.

As it is, tremendous progress has been made in the last twelve months in converting raw material into fine copper by the electrolytic process. Not alone have old works, like those at Bridgeport and those of the Balbach Smelting and Refining Company at Newark, N. J., been considerably enlarged, but new ones have been started at Baltimore and Anaconda, and still another plant is in course of erection at Great Falls, Mont., for the Boston and Montana Company, which will commence operations within three months, as well as one in Northern New York and one or two in New England. We estimate that the production of electrolytic copper in the United States in 1893 will be about 75,000,000 lbs., and there will be a correspondingly smaller proportion of furnace material to be exported.

The following excellent *résumé* of the conditions affecting the copper market, and consequently the entire industry, during the year 1892 is contributed to this work by a gentleman who is familiar with every department of the copper industry on both sides of the Atlantic:

"An examination of the 'Statistics of Copper' published by the *Engineering and Mining Journal*, and by Messrs. Henry R. Merton & Co. of London, gives some facts which may be of interest to the readers of your statistical volume. Comparing 1892 with the two previous years, we find that for the twelve months ending Oct. 31 in each of these years the average statistical stocks, deliveries, and prices were as follows:

	Average Stocks.	Average Monthly Deliveries.	Average Price G. M. B.
1890	83,918 tons.	12,283 tons.	£53 8s. 2d.
1891	60,459 "	10,479 "	£52 10s. 8d.
1892	56,719 "	8,884 "	£45 3s. 11d.

So that 1892 compared with 1890 shows a decline of over 15% in price coincident with a decline in stocks of over 33%; and this does not tell the whole story, because in 1890 large stocks of copper were held in private warehouses on the Continent and in England, while in 1892 these have nearly or quite disappeared. One unfavorable element of comparison, namely, the smaller average deliveries in 1892, is more apparent than real, because the published statistics include returns of English and French trade only. The failure of the Société des Métaux transferred a considerable proportion of the Continental trade

from France to Holland, Germany, and Austria, and during the last 18 months a good deal of business has passed from English to German manufacturers, so that probably the European consumption of 1892 was as large if not larger than that of 1891. To what, then, is the low average price of 1892 due? I believe primarily to the necessity of absorbing the large stocks of ingot and cake copper left in the bankers' hands by the failure of the Secretan syndicate, and secondly to the faulty methods employed by the producers in distributing their copper for consumption. Large quantities of refined copper were delivered to the Secretan syndicate as G. M. B. during the last few weeks before its failure.

"As all will remember, the great fall in price consequent on the syndicate's failure was followed by an advance due to the heavy purchases made by manufacturers and smelters to replace the working stocks which had been sold to the syndicate as G. M. B. The return of these stocks to their normal condition and the Baring failure in the fall of 1890 changed the nature of the buying. Instead of consumers buying ahead for their needs, they commenced buying from hand to mouth, and again reduced their working stocks to the lowest possible point. Instead of producers meeting this condition by a decline in production, they actually increased it, and the air was full of rumors of still greater increases to come. In order to secure a place in the market, the principal producers and the bankers sold to dealers and speculators large quantities of copper for future delivery. The copper in the hands of the bankers being of poor quality, it was sold at comparatively low prices. A large sale of Lake copper was made for account of one of the American mines at a very low price as compared with the existing price of G. M. B., and large contracts for future delivery of furnace material were made, the price to be fixed by reference to a standard of the average price of G. M. B. and Best Select at the time of delivery. The purchasers of the block of Lake copper are said to have sold G. M. B. against their purchases. The smelters sold refined copper for forward delivery at fixed prices, and as the price of their raw material was partly dependent on the price of Best Select copper, they were not too particular about holding up this price. The dealers who obtained their supplies from the bankers were also competing; and so, although there was a consumptive market which actually took all the copper that was produced and caused a heavy decline in the existing stocks, yet all these interests being in favor of a fall in price, and none of the producers being prepared to support it, the price continued to fall, with some temporary interruptions during the latter part of 1891 and early part of 1892.

"In 1892 rumors of the mining companies trying to reach an agreement to limit production caused a temporary advance in price; but this, being followed by further sales of furnace material from America on the old standard of G. M. B. and Best Select, was at once checked, and low prices continued until October, 1892, when it was found that the end of the stocks of refined copper in the bankers' hands had been reached, and that the result of various exchanges by the residuary legatee of the Secretan syndicate with Continental dealers of refined copper for ordinary Chile bars had brought more than one half of this, the true medium of speculation, into the hands of one party. Buying by dealers who had to deliver 6000 tons to Baron de Hirsch in exchange for refined copper, and by speculators to cover short contracts, again advanced the price. But this advance

was again checked by heavy sales of furnace material from America. These sales, however, were nearly all for immediate shipment, and at a fixed price.

"The situation at the end of the year is this: The European consumption is good; the demand for copper for electrolytic purposes is constantly increasing; and the belief is prevalent among European consumers that the price of copper has been too low, and all are prepared for higher prices. The European stocks of copper at present represent less than four months' consumption, and the unknown stocks—that is, stocks in the hands of the consumers—are at the lowest point consistent with actually carrying on work.

"If sales be confined only to present delivery at fixed prices, the natural competition of buyers who feel the necessity of carrying more stock in anticipation of rising prices will, without doubt, advance prices to at least the level of 1891, and those persons in Europe best qualified to judge of the position expect that such an advance in price will take place next spring. It will be prevented, however, if dealers and speculators are supplied with ammunition for another 'bear' campaign through contracts for deliveries over long periods of time, at prices to be fixed at the time of delivery, or by sales of large blocks of material to speculative dealers at comparatively low prices.

"When it is remembered that the actual total consumption of copper is approximately 300,000 tons, and that at the difference in price between 1890 and 1892 the annual loss to the producers on the sale of copper is almost equal to the total value of all the stocks in England and France on Oct. 31, 1892, at the then market price, it will readily be seen that producers can well afford to support the market.

"The price for 1893 will probably be settled in February or March. If the silver question were out of the way, the price would certainly be higher than at present, and in any event that will probably be the result."

The course of the American market during the year is summarized as follows:

The year opened with Lake copper quoted at 11c., at which price the Calumet Company sold fairly large quantities to manufacturers. Up to the end of February prices slowly fell off to 10⅝@10¾c. for Lake and about 10¼c. for casting. Europe was rather flat owing to several failures there, and offered us no support; besides, European smelters were able to contract for from 15,000 to 20,000 tons of Anaconda matte for shipment during the current year, at prices based on those for G. M. B.'s and Best Selected copper. At this time the Calumet and Hecla Company sold about 5000 tons at 10½c. to consumers. Early in March it was reported that the combination previously referred to was likely to materialize soon. On the strength of this the market suddenly took a turn upward, and with hardly anything selling (except by the Calumet Company, which supplied a few thousand tons to consumers at 11c.), prices jumped from 10¼c. to 12⅛@12¼c. for Lake and to 11⅝@11¾c. for casting copper.

Europe advancing simultaneously, a large business was done in Arizona pig copper, which had been withheld from the market for about three months. When the first excitement was over, the market eased off slightly, but values were quiet during April and May, with Lake at 12c., casting at 11¼@11⅜c., and a good consumptive demand noticeable.

At the end of May the first shipments by rail and lake arrived from Michigan

and prices flattened, touching $11\frac{3}{4}$c. in June; in July and August they declined to $11\frac{1}{2}$c., with sales of small quantities at even a little less, casting copper being then quoted at $10\frac{5}{8}$@$10\frac{3}{4}$c. At this time it became known that a decision regarding the restriction of production had been reached, but the effect was slight, as many people doubted whether it would prove binding. The summer months passed without much life being infused into the article, which fluctuated more or less, and at the beginning of October was again quoted at 11c., but the quantities available at this price were rather small. The larger companies remained out of the market, and, the consumers being in urgent need of material, their buying slowly forced the market up to $11\frac{1}{4}$@$11\frac{1}{2}$c., a great deal of business being done. To harden to 12c. took but a short time, the result being helped along by the spreading abroad of rumors that the Anaconda would close down on Nov. 10 for a period of three months, and that the Boston and Montana and Butte and Boston would do likewise. Nothing of the sort happened, and from reliable quarters we hear that it was only intended to stop for a little longer time than usual when stock-taking commenced. We can see no necessity for the adoption of such violent measures.

At the end of November the market was firm at $12\frac{1}{4}$c. for Lake and about $11\frac{1}{4}$c. for casting copper, and it was said that large speculative purchases had been made in London for account of America, the object being to stiffen prices there.

The beginning of December saw a still further stiffening. The price of Lake was advanced to $12\frac{1}{2}$c., 12.20c. being freely bid for ingots and 5c. per hundred more for cakes and wire-bars, $11\frac{1}{2}$c. being the price of casting, for which there was a good demand, and $10\frac{3}{8}$c. that of Arizona pig copper. The effect of the speculative purchases of G. M. B. copper on the other side was also felt at the same time that the quotations advanced to the highest figures known since October of last year, viz., £47 17s. 6d. for spot and £48 7s. 6d. for three months prompt. After this there was a slight easing off all around, and we close the year at $12\frac{1}{4}$@$12\frac{3}{8}$c. for Lake, a cent cheaper for casting, and $10\frac{3}{8}$c. for Arizona pig copper, the G. M. B. market in London being £46 15s. for spot and £47 5s. for futures.

The manufacturers of copper, etc., may have cause to complain of the prices realized for their product, but it is known that during the year the volume of business has been very satisfactory; large orders for wire have continually been in the market, and we doubt not will continue to be for some time to come. The telephone between New York and Chicago—a noteworthy achievement—has called for considerable copper, and as it is likely that more long lines will be built, there will of necessity be a corresponding demand for wire.

The combination of sheet-copper manufacturers has continued throughout the year to exact prices for their product far above what the price of ingot justified. This combination has for years been a great injury to the producers, the high prices demanded limiting the growth of consumption.

In the accompanying table is given the average price actually received by each of the companies named in each of the years specified. These averages are obtained by dividing the amount credited as receipts from copper in the treasurer's reports by the number of pounds sold. The wide differences between the average prices received in some years by the different companies is accounted for partly by the fact that the fiscal years during which the sales were made did not always

end at the same date for all the companies, and is partly due to the greater or less proportion of the output of the company sold when the market was high. These average prices actually received do not, therefore, represent the average market price for the metal during the year, but are not, on this account, less valuable and instructive; they have been used as the basis for estimating the probable receipts of the Calumet and Hecla Company, from which we deduce its cost of producing copper. The gaps in the table are due to the absence of reports by the directors, in some cases because the mines were under lease.

AVERAGE ACTUAL SELLING PRICE OF LAKE COPPER PER POUND.

Year.	Allouez.	Atlantic.	Calumet and Hecla.	Central.	Franklin.	Huron.	Kearsarge.	Osceola.	Quincy.	Tamarack.*
1865....	....	....	....	32.78	30.70	....	....	....	....	....
1866 ..	....	....	....	29.96	29.09	....	....	....	31.11	....
1867..	....	....	....	24.74	23.50	....	....	....	23.8	....
1868 ...	....	....	....	24	23.71	....	....	....	24.66	....
1869....	....	....	....	22.39	22.66	....	....	....	21.85	....
1870....	....	....	....	20.47	18.85	....	....	....	21	....
1871....	....	....	....	22.66	23.79	....	....	....	23.50	....
1872....	....	....	....	30.43	33.60	....	....	....	32.33	....
1873....	....	26.66	....	29	....	....	....	....	26.50	....
1874....	....	22.32	....	20.81	....	....	....	23.37	21.80	....
1875....	....	22.47	....	22.56	....	....	....	22.77	22.60	....
1876....	....	21.35	....	20.86	....	....	....	20.57	20	....
1877 ...	....	18.54	....	18.36	....	....	....	18.19	16.5	....
1878....	....	16.15	....	15.84	....	....	....	15.53	....	....
1879 ...	....	16.3	....	15.50	....	....	....	17.79	....	....
1880 ..	....	18.81	....	18.18	....	....	....	19.15	....	....
1881...	18.80	17.12	....	17.14	....	20.27	....	17.77	18.50	....
1882 ...	17.86	17.56	....	17.46	18.17	18.35	....	17.70	17.30	....
1883....	15.13	15	....	15	15.66	15.68	....	14.96	14.90	....
1884....	13.02	11.81	....	11.99	12.11	13.87	....	12.82	12.20	....
1885....	11.02	11.16	....	11.15	11.04	10.92	....	10.75	12.10	....
1886 ..	14.80	11.00	....	10.59	10.87	10.98	....	10.51	10.80	10.55
1887 ...	10.38	12.12	....	12.12	11.84	12.13	16.00	11.86	11.80	10.24
1888 ..	13.60	14.78	....	14.80	14.49	14.91	16.80	15.30	16.70	13.90
1889 ...	12.09	12.09	....	12 57	12.29	12.82	12.58	11.94	11.90	12.90
1890 ..	14.73	14.94	....	14.94	14.79	14.86	15.08	15.51	15.40	11.99
1891 ..	12.06	12.57	....	12.02	12.61	....	12.38	12.51	12.8	14.01
1892 ..	11.44	11.83	....	11.83	....	....	....	....	....	11.35

* Fiscal years ending June 30.

AVERAGE PRICE PER POUND OF LAKE COPPER AT NEW YORK.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1860..	23¾	23⅞	23⅜	23¾	22⅞	22⅛	21⅝	21½	21⅝	21¾	20⅞	20	22¼
1861..	19½	19¼	19½	19⅜	19½	18½	17¾	18⅜	19⅝	20⅛	21⅜	24¾	19⅛
1862..	27½	26½	24	22¼	21⅛	21⅞	23½	24¼	25⅝	29⅞	31⅝	31	25¾
1863..	33	36	34	30½	30¼	30¼	30½	30	31⅝	33⅜	36¼	38⅝	32⅞
1864..	40⅛	41⅝	42	43¼	43⅛	46½	59¾	51¼	50	47½	48	49¼	46¼
1865..	48¼	45	39¼	34½	32	29½	29⅛	31⅛	31⅞	32½	39⅛	42⅜	36¼
1866..	40	36¾	32½	29¼	29⅞	32½	32¼	30⅝	31⅛	30⅞	28¾	27¾	31¾
1867..	28⅛	27½	25¾	24	24⅛	24¼	25	26	26¾	24¾	22⅞	22⅝	25⅛
1868..	22½	23¼	23½	23¾	24⅛	23⅝	23¾	24⅛	23⅞	23½	23¼	24⅛	23⅝
1869..	25	26½	25⅜	23⅝	24	22⅞	22	22½	22½	22⅜	22¼	21¾	23⅜
1870..	21⅜	20⅞	19¾	19⅛	19	19¾	20⅜	20½	21⅛	21¾	22¼	22¼	20⅝
1871..	22⅛	21⅞	21½	21½	21¼	21⅜	22⅛	22¾	23⅜	23½	24⅛	26⅛	22⅝
1872..	27¾	28⅜	33	41¼	36½	33½	33¼	33½	33⅛	32⅛	31⅜	32¼	33
1873..	34¼	34⅝	34¼	33¼	31⅛	29¼	27¾	27⅛	26	23¼	22⅛	24¼	29
1874..	24¾	24⅝	24⅜	24⅞	24¾	24⅜	21⅞	20	21⅛	21¾	2 ¾	23½	23¼
1875..	22¼	22¼	21½	21½	21½	22¾	22¾	23	23¼	23⅛	23	23⅜	22½
1876..	23⅛	22⅝	22	22	21⅞	20	19¾	19	20	20¾	20¼	19¾	21
1877..	19¼	19¼	19¼	19⅜	19⅛	19⅛	19	18½	18	17⅞	17⅝	17⅝	18⅝
1878..	17½	17¼	17	16⅞	16½	16¼	16⅛	16⅛	16	15¾	15⅝	15⅞	16½
1879..	15¾	15½	15¾	15⅞	16	16⅛	16	16⅛	16½	19½	21½	21¼	17⅛
1880..	23	24⅛	23¼	21¾	19	18⅛	18½	19	18¾	18¾	18¾	19	20⅛
1881..	19¼	19¼	19⅛	18⅞	18½	17	16¼	16⅝	17⅛	18⅛	18⅛	19¾	18⅛
1882..	20¼	19½	19	18⅞	18⅛	18⅛	18⅛	18⅛	18⅛	18⅛	18	18	18½
1883..	18	17¾	17¼	15⅞	15⅞	15½	15	15	15⅛	15⅛	15	14⅞	15⅞
1884..	14⅞	14⅞	14⅞	14½	14¼	14⅛	14	13⅞	13⅛	13	12¾	11⅝	13⅞
1885..	11¼	11⅛	10⅞	11	11½	11⅜	11⅛	11⅛	11⅛	11	11	11¼	11⅛
1886..	11⅜	11⅜	11⅜	11⅜	10¼	10	10	10	10½	11¾	12	12	11
1887..	11⅝	11	10½	10¼	10	10	10⅜	10½	10½	10½	12⅝	17	11¼
1888..	16¼	16⅜	16⅛	16⅝	16⅜	16½	16¾	16¾	17¼	16½	16½	16½	16⅔
1889..	17¼	16⅞	16¼	16½	12¾	12	12	12	11	11	12⅜	14⅜	13¾
1890..	14⅘	14⅓	14½	14⅖	15⅓	16	16⅘	15⅖	17	16 9/10	16⅘	15 9/10	15¾
1891..	14¾	14½	14	13¾	13⅕	13	13	12⅕	12⅛	12¼	11	10⅗	12⅞
1892..	11	10⅗	10⅜	11½	11⅝	11⅞	11½	11½	11⅛	11½	11⅞	12⅜	11½

Sales Note Form.—Since the English market is now willing to buy furnace material delivered here on American assay it will be of interest to give here a *pro forma* sales note, or form of contract, which would be considered fair in the United States as between buyer and seller:

Sold this........day of..............189...to...........................of ....tons (2000 lbs. each) of argentiferous copper matte, to be delivered free on board vessel, within the lighterage limits of the port of New York, as follows:

....

Payment to be on the following terms:

The matte shall contain not over....% of lead and between....% and....% of copper and......oz. and......oz. of silver per ton of 2000 lbs. The payment is to be based upon the assays and weights of Messrs...................., assayers, which are to be final and binding on both buyer and seller, but both parties can be present at the sampling if they so desire. The assays shall be the American fire assay for copper—that is, the electrolytic assay, less 1.3 unit—and the scorification assay for silver. The price to be paid is....cents per pound of fine copper, and 92½% of the New York value for silver on the date of assay certificate, as noted by Messrs, Nesslage, Colgate & Co. The assayers to render duplicate certificates of weight and assay to both buyer and seller.

Sellers not to be held responsible for delays caused by strikes, delays in transportation, or any accident over which they have no control.

The London Copper Market in 1892.

The year 1892 opened with G. M. B.'s at £46 13s. 9d., but further purchases for French account advanced them to £47 6s. 3d.; from this there came a reaction due to various causes, the principal one being the anticipations of large American exports.

Business with the East was much affected by the decline in silver, a factor which later in the year increased in importance. The Birmingham quarterly meeting of the metal trades revealed a considerable amount of depression in manufacturing circles. This condition of things was not encouraging to speculators, and the value of G. M. B.'s accordingly dropped until at the close of the month (January) £44 11s. 3d. was reached. Statistics also showed an increase of nearly 1500 tons in the visible supply—owing to the method, then newly adopted, of taking out of the figures of stock only furnace material actually delivered, instead of, as formerly, all furnace material merely sold. Sixteen hundred tons of furnace material which had been sold to smelters for forward delivery would, under the old method, have been treated as actual deliveries.

February opened with a sharp drop in G. M. B.'s from £44 10s. to £43 10s., due in part to rumors affecting the credit of some important financial establishments, but which afterward proved to be without foundation.

The resumption of competition which had been inoperative since May of the previous year—the Anaconda mine—affected the market; 7000 tons of this argentiferous matte were sold to smelters here for delivery over the remainder of the year, the average of G. M. B.'s and Best Selected forming the basis for the transaction. About 1100 tons of argentiferous matte (chiefly Boston and Montana) were sold to producers of electrolytic copper. The fall in silver to 38½d. (the lowest price until then on record), the weakness of the American market, and the poorness of consumptive demand at home, also depressed the market. Consumers were working on low stocks and buying only from hand to mouth, and any little spurt in G. M. B.'s tended to bring out their inquiries.

March was a month of almost uninterrupted advance in G. M. B. values, due to rumors relating to restriction of production. These reports had been in the air for some time, but now it was said that the American producers had agreed among themselves, subject to the Europeans joining. The negotiations were continued over March, April, and May, when a definite agreement was concluded. One of the principal elements of depression had for a long time past been the fear of heavy shipments from America.

Despite the fact that the Anaconda mine had worked only seven months in 1891, the statistics of the production of the world, published in March by Messrs. Henry R. Merton & Co., showed an increase that year of 6000 tons; and it was felt that an agreement, even if it merely secured restricted and not reduced production, would, by guaranteeing Europe against an inundation of American copper, tend to strengthen the market, for European supplies had decreased largely.

The market became buoyant, and after touching £43 18s. 9d. at the beginning of the month the value rapidly advanced, stimulated by speculative purchases, largely emanating from America (where Lake had advanced to 11¾c.), until toward the close of the month £47 15s. was touched. At this point people began taking their profits, and the realization induced a relapse to £46 17s. 6d., and then to £45 5s., the heavy fall in silver, 39d., having assisted the decline.

April was an uneventful month. Trade here was dull and values comparatively low, and the difference between prices here and in the States was illustrated by the actual resale and reshipment to America of some Arizona copper which had risen to 11¾c. in New York. The leading peninsular copper companies' dividends all showed a heavy falling off as compared with 1891. Spot G. M. B.'s declined to £45 5s., recovered to £46 7s. 6d., touched £45 2s., and closed at £45 13s. 9d.

May—with the probability, daily increasing, of a successful issue to the negotiation between the producers—was a month of advancing values. The price of cash G. M. B.'s improved to £46 8s. 9d. in the first fortnight and then rose to £47 10s. A relapse to £45 5s. was followed by a fresh rise to £47 2s. 6d.

At the end of May the long-expected agreement between producers became an actual fact. Under its provisions the American group, which produced in 1891 about 115,764 tons, was authorized to produce in the year ending July 1, 1893, about 125,217 tons, while the European group, whose output for 1891 was 82,900 tons, was allowed a maximum of about 84,259 tons. The net result was, accordingly, an optional increase for the year named of about 10,812 tons for the combined producers; or, assuming the output of mines outside of the agreement to be the same as in 1891,—say about 77,000 tons,—the net result would be a total increase

to the extent of 10,812 tons for the world. The immediate effect of the agreement was to induce realization and sale, in consequence of which G. M. B.'s dropped to £46 12s. 6d. In New York spot copper was scarce, and Lake rose to 12¼c. for prompt delivery. Here copper was in poor demand, the only exceptions being electrolytic and India sheets.

A fair business took place in G. M. B.'s in the early days of June at prices ranging from £46 3s. 9d. to £47, the latter figure proving the highest of the month. The mid-monthly statistics revealing an increase for the fortnight of about 1700 tons, they produced an unfavorable impression, and with the exhaustion of buying orders the market fell away, the following stages being passed in rapid succession, viz.: £46 7s. 6d., £45 10s., £45, and finally £44 16s. 3d., the closing value.

In furnace material the principal transactions were a further 600 tons of Anaconda matte on average terms as before, 500 tons ordinary Montana matte at 9s. 4½d., 600 tons argentiferous matte on private terms, and 1300 tons Namaqua ore at 8s. 6d. per unit.

As to general trade, refined copper was dull. In India sheets and yellow metal, however, a rise in the Eastern exchanges produced a slight improvement. In America the quotation for Lake was reduced to 11.50c., and holders evinced rather more disposition to make sales to Europe.

Throughout July we had a market devoid of buoyancy. Fluctuations in G. M. B.'s were much less wide than in the preceding month. Opening at £44 12s. 6d., we touched £45, and then dropped to £44 8s. 9d. The publication of the statistics for the first half of July, although showing the very large increase of 2270 tons in 14 days, was practically without effect on the market; and, indeed, the same week witnessed, after a fall from £44 16s. 3d. to £44 10s., an advance to £45 3s. 9d., due to purchases chiefly on American account. This large increase in visible supplies was due to the fact that the Anaconda Company had produced and shipped as heavily as possible prior to July 1,—the date when the producers' agreement was to go into force,—and it was well understood that the benefit of the said arrangement could only be felt a little later in the year. Other points of interest to be named are a good consumptive demand in America; the buying-up of the second-hand stock of Lake there at 11.50c., and the advance in price to 11.75c.; the gradually dwindling European stock of French Syndicate copper (although the report that the only remaining original holder had been clearing out was not correct, it seems that some of the other large holders had for some time past been quietly disposing of their holdings, and had now at length cleared out); the sale of about 4000 tons ordinary and 300 tons argentiferous Anaconda, and of 1300 tons Quebrada regulus, all on private terms. As to manufactured copper, makers here complained much of the lack of new orders, and the trade in refined sorts—in harmony with this state of things—was decidedly slow.

August opened at £44 18s. 9d. for spot G. M. B.'s, the value of which was only slightly depressed—viz., to £44 12s. 6d.—by the July statistics, showing an increase of 3134 tons for the whole month, these figures being rather better than had been anticipated. American exports for the first seven months of this year were about 7500 tons less than for the same period of the previous year. That the European supplies, in spite of this, had increased, was mainly due to the widespread and

prolonged depression in trade. The heavy fall in silver this month—viz., to 38$\frac{7}{8}$ 1$\frac{1}{8}$d. under the previous lowest record—made India a seller instead of a buyer of refined copper. Later in the month, however, a slight recovery in silver reversed this state of things, and enabled a business of some 1000 tons of copper and yellow metal sheets to be put through. The G. M. B.'s market closed, after a very dull spell, with a drop to £44—a shade firmer at £44 7s. 6d.

September opened with a slight improvement in the speculative market, induced by the improvement of over 2000 tons in the statistics for the second half of August. There was paid £44 10s. for spot, but the firmness proved only momentary, and the first three weeks of the month were characterized by a slow but steady decline in values, amounting to about £1 in all, £43 11s. 3d. being eventually reached. Not without influence on our market was the equally flat state of things in America, where prices also receded, and where the trade in refined copper was, so to speak, at a deadlock, consumers aiming at lower prices and smelters declining to come down. Lake was nominally held for 11.15@11.25c. The last week of the month witnessed a reversal of the above conditions. The conviction seemed to have gained ground that, while copper was not likely to recede much further, it was by no means improbable that it might advance. This change of feeling found expression in very considerable speculative purchases, some 4000 tons being bought in the last week of the month with a rise in price to £44 5s. Consumers' copper also shared in the improvement, home manufacturers, the Continent, and India all buying moderately, while smelters purchased furnace material and Chile bars more freely.

The upward movement made further progress early in October, aided by a more buoyant feeling in nearly all markets, and also by the statistical factor, the second fortnight of September showing a decrease of 1819 tons, or 1236 tons for the whole month. A large business was again done in G. M. B.'s at improved values; £45 10s. was paid in the first week, and £45 13s. 9d. in the second week. In the third week a further improvement in statistics (1772 tons for the first fortnight), together with the official report that the Anaconda mine was to close for three months from Nov. 10, gave added strength to the market, G. M. B.'s rising to £46 1s. 3d. for spot, the highest point in the movement. During the remainder of October the market was a shade easier, but the lowest price touched was £45 11s. 3d. Refined sorts were scarcer and were firmly held. The demand was not particularly good, except for electrolytic and other finest sorts. The firmer silver market, however, enabled business to be done with India in yellow metal, and there was also a fair demand for copper squares. In America producers had got the best in the waiting game alluded to above—consumers having at last been forced to cover their requirements, and Lake rose to 11.62$\frac{1}{2}$c.

One feature of the year which we must not omit to mention is the great falling off in the demand for and manufacture of sulphate of copper; this alone accounted to a not inconsiderable extent for the poorer deliveries and unfavorable statistics during a good part of the year.

The official figures of the production of the mine owners belonging to the combination—for the first three months of its working—showed that the actual output of Europe, and the American output and exports, were all considerably under the permissible rate. For example, America produced 32,599 tons; that is, at the annual

rate of 130,376 tons against the optional maximum of 136,726 tons, while the European output amounted to 18,724 tons, equal to an annual rate of 74,896, intead of the optional maximum of 85,019 tons. The shipments from America were 6453 tons; that is, at the rate of 25,812 tons per annum instead of 40,000 tons.

The first fortnight of November was distinguished by steadiness of tone and only moderate variations in the G.M.B.'s market, viz., £45 13s. 9d. to £45 7s. 6d s.c. A feature in the week ending Nov. 12 was the repurchase of Lake at £55, and at the close of that week there was more disposition evinced to buy—1200 tons G.M.B.'s changing hands on the 11th. The next week opened firm, the principal factor being the scarcity of furnace material. Besides the above-named announcement of the temporary closing of the Anaconda mine, there now came a rumor to the effect that the Boston and Montana and Butte and Boston mines were to close down for a period of three months at least. This position of things led to considerable purchases of G.M.B.'s, which rose on the 15th inst. to £47 s.c. We close to-day (the 15th) at £46 15s., s.c., and £47 5s., 3 months. English tough copper is quoted £50@£50 10s., best selected £50 10s.@£51, strong sheets £59, India sheets £55, and yellow metal sheets 5⅛d.

PRICES OF CHILE BARS IN POUNDS STERLING PER TON OF 2240 LBS.

Year.	Stocks, Tons.	Jan. £	Feb. £	Mar. £	April £	May. £	June. £	July. £	Aug. £	Sept. £	Oct. £	Nov. £	Dec. £	Year. £
1866	29,388	95	93	88	86	80	83	79	74	83	80	75	72½	82⅞
1867	32,084	70	76	74	71	71	73	70½	68	73⅛	68½	68	69⅛	71⅝
1868	33,500	67	69½	71	73⅛	77½	77	75	68½	68	67	69	69	71
1869	41,921	73¾	73¾	72½	71	70½	68	67½	68	68½	67½	67½	66¾	69⅛
1870	43,365	66½	66¾	66¼	65¾	67¾	67¼	68½	63½	63½	63½	62½	62¾	65⅝
1871	40,092	64½	63½	66¼	64¾	65¼	67¼	68¼	68¾	67½	68½	68	76	67⅛
1872	36,497	86¾	85	83½	99¾	101	107½	103	102	91	83½	86	84¼	92⅞
1873	41,082	91	87⅛	85	91	88½	84½	80½	81½	84½	83	83½	83½	85¼
1874	36,868	83⅜	81⅛	77	75	74	74	78	76	77⅛	80	83½	83½	78⅛
1875	36,316	84	83	82	80	83	83	82	79	82½	82½	82	87½	82⅛
1876	36,962	81½	81	76½	77½	79½	77½	74⅛	72½	71¾	72¼	76⅛	81	76⅛
1877	42,313	76½	73	71⅛	70½	68¾	69	69	69	67⅛	65½	65½	76½	70¼
1878	48,399	65¾	65¾	63	63	62	64½	64	61½	61¼	60	57½	63½	62⅞
1879	57,837	58	56	54¾	56	56	55	56	53¼	54¼	58¾	66	58½	58⅞
1880	62,855	65¾	73¼	70¾	65½	60	56¼	60	61	61⅛	61¼	61	66½	63⅛
1881	58,149	61¾	62	61	61	59	59	58½	59	59	62¼	63¼	67	61⅛
1882	49,696	71	64	64	64¼	63¼	63½	67	68½	67¾	71	69	66¼	67
1883	49,878	65	65	65	64¾	62⅞	63¾	64	63⅝	64	63	61¼	59½	63⅛
1884	45,880	56½	55⅝	53⅞	56½	56	54⅛	55	53⅞	54⅛	52⅝	51¼	47¼	53⅞
1885	55,939	48¾	47⅝	46¼	44⅛	44⅝	44⅞	44½	43¼	41⅞	39⅞	41⅛	41⅝	44
1886	61,741	40¼	40¼	42⅜	41¾	40⅛	39⅞	39⅜	39½	40¼	41½	40⅜	39¼	40⅛
1887	42,301	38⅞	39⅜	39⅛	39⅜	39¼	40	40	40⅛	39¾	44¼	66¾	75¾	45¼
1888	104,105	85	77⅛	78⅞	80⅛	80⅛	80¾	81	80⅛	89	100	78¼	77⅛	82⅝
1889	98,847	77½	77½	78	39¼	37¾	41	41⅛	42	43⅛	43	44⅛	50⅛	51¼
1890	65,636	48⅞	47	47½	49⅛	54½	58½	57	60¼	59⅛	58½	55½	53⅛	54⅛
1891	57,420	52½	52½	52⅜	52½	52⅛	53¾	54	52⅞	52⅛	49¼	45¼	45½	51⅜
1892	55,462	44⅝	44¼	46¼	45⅝	46⅝	44⅞	44⅞	44⅝	44⅛	45⅝	47⅞	46⅞	45⅛
1893	....	46⅛	45¾	45⅝	45	43¾	44	43	41½	42⅝	42⅛	42⅝	43¼	43¾

AVERAGE YEARLY PRICE OF COPPER IN GERMANY.*

(Prices in marks per 100 kilos; one mark = 23.8 cents.)

Year.	Berlin.		Frankfort-o-R. German Double Refined in Plates and Ingots.	Hamburg, English Ingots, Bars, Mark, T C T.	Year.	Berlin.		Frankfort-o-M. German Double Refined in Plates and Ingots.	Hamburg. English Ingots Bars, Mark T C T.
	Mansfeld.	Foreign, A1, Mark Beede.				Mansfeld.	Foreign, A1, Mark Beede.		
1879	133.42	....	126.75	134.07	1887	......	....	94.08	92.89
1880	149.08	....	135.06	140.79	1888	160.05	....	154.21	157.00
1881	140.58	....	131.90	136.43	1889	118.50	....	110.92	115.44
1882	146.81	....	140.50	150.24	1890	129.75	119.67	121.33	122.31
1883	141.27	....	135.17	140.69	1891	119.50	111.56	111.54	116.02
1884	125.58	....	119.13	126.09	1892	107.35	99.42	97.92	100.54
1885	106.46	....	95.29	97.55	1893	101.58	96.33	95.04	97.52
1886	93.41	....	86.40	88.13					

* From *Vierteljahrshefte zur Statistik des Deutschen Reiches*, 1894, Vol. I.

The Cost of Producing Copper.

The earning of profits on investment is the object of mining. As the prices realized in a fully supplied market are regulated, in a large way, by the average cost of production, it becomes extremely important to ascertain as closely as possible what this is and is likely to be, if we would forecast with any degree of reliability the future market for a metal or the future outcome of an investment. The actual average cost of producing copper is not generally appreciated, partly because of the peculiar systems of accounting that prevail in this as in other industries which are more or less speculative and in which there is a temptation to charge up as an asset, under some euphonious title, expenditures that should properly be counted as working expenses in the cost of the metal produced. Moreover there are very few mining companies in this country that charge off any part of their investment against earnings; on the contrary, nearly all have an "improvement account" or a "capital account" which easily absorbs all kinds of expenditures and leaves larger apparent profits. After a time the mine is worked out and the entire so-called "assets" in "real and personal estate" or "improvements" disappear, for neither improvements nor real estate have any value when a mine is exhausted.

In order that the facts may be appreciated, and at the same time to show the effects upon cost of improved methods of mining, reduction, and transportation,—in short, to show the progress in the art,—we have compiled, with great care and labor, from the official reports and treasurers' statements of several companies, a number of tables showing the actual cost of producing copper at certain Michigan mines, and we have done a similar service in the cases of certain gold and silver mines. The value of these tables as well as the great amount of labor involved in their compilation will be quickly recognized, and they will perhaps lead, in some cases, to a closer inquiry into the administration that shows such irregular and unexplained results. Fortunately in the case of the copper mines we have examples of such admirable management as that of Mr. John Stanton, who administers the business of the Atlantic, Allouez, and Central mines. The accounts of these companies are made public in such detail that it is comparatively easy to study the effects of such improvements as the introduction of rock-drills, high explosives, steam stamps, etc., on the cost of production.

In each tabulation we have taken as a starting-point the original investment, and have not attempted to write it off, though a prudent management would provide a sinking fund for its gradual extinction.

We have taken the entire receipts of the company, deducted from these the dividends paid and the increase in the net *cash* balance, or added the amount by which this was diminished (if the company paid more dividends than it earned), and the result is a gross sum which measures, without any illusions, the cost of production for the year. Wherever the data were available this cost is itemized under the more important heads so as to follow year by year the cost of doing the work. "Improvements" of all kinds, machinery, purchases of timber lands, and all other such items are charged up, when expended, as part of the

cost of production. If to this were added a fair sinking fund to extinguish the original investment, it would give, when the mine was finally worked out, the total actual cost of its product.

In the case of the Atlantic we have an admirably managed property, paying dividends regularly from a mine constantly becoming deeper and more extensive, and an ore declining in yield until the total value of the copper obtained from a ton of rock milled is only about $1.60. Considering the amount of work done in mining, sorting, transporting three miles from the mine to the mill, stamping, concentrating a rock containing .65 of 1% of copper, sending the concentrates a thousand miles to the smelters, smelting and refining, marketing the product 1500 miles distant from the mines, paying wages which make average earnings from $45 to $55 a month for the entire force at the mines, and then declaring dividends—this is an example of skill and economy which is, I believe, unequaled in any other district in the world. The Atlantic is not, however, the only admirably managed mine in the Lake district; some of the others are also given in these tables.

There is, naturally, some connection between publicity and economy. The mines that make public in greatest detail their expenditures are the most economically managed, and secrecy in administration apparently induces, or is induced by, extravagance in management. Whatever may be the reason given for a refusal to furnish stockholders with such detailed information as is necessary to enable them to understand how *their trustees*, the directors, are administering their trust, the fact is absolutely certain that secrecy always covers extravagance, and not infrequently dishonesty.

In the case of the Central—which is known as a "mass" mine, where the copper occurs in large masses and is not evenly distributed through the ore—but a small part of the ground broken is productive or goes to the mill. The expenses per ton milled are therefore apparently very high, while in reality the work is actually done very economically. The ore of the Osceola, the Tamarack, and the Calumet and Hecla is harder than that of the Atlantic, as is shown partly in the higher cost of stoping and drifting.

These tables give in the first column the year. In the second column the amount of capital paid in is stated in thousands of dollars. The third column gives the tons of ore stamped; the fourth column, the pounds of copper produced; the fifth column, the percentage yield of ingot copper; the sixth column, the average price at which the copper was actually sold as given in the treasurer's accounts; the seventh column, the total receipts from sales of copper, and in some cases from rents, interest, and other sources of income. Under the heading of "Cost" is given in the eighth column the cost of mining, in cents, per ton of rock mined—and this includes all underground expenses, such as timbering, tramming, pumping, hoisting, etc. The ninth column gives the cost per ton of hauling the ore from the mine to the mill—in the case of the Atlantic about three miles; the tenth column, the surface expenses, landing, and all general expenses on the surface not included in the next item; the eleventh column, the costs per ton for stamping and concentrating and all expenses about the mill; the twelfth column, the smelting cost per pound of copper. As all the concentrates—or "mineral," as they are termed—carry from 65 to 85% of copper, the cost is given

ATLANTIC MINE.

Year.	§Capital Paid in.	Stamped.	Copper Produced	Yield, per cent.	Sell'g Price pr.Lb	Total Receipts.	Cost. *Min'g pr.Tn.	Haul'g to Mill	Surface Exs.	Stamp'g pr. Tn.	†Smelt'g perLb.	‡Brok'ge pr.Lb.	Impr't. per Tn.	Total per Lb Copper.	Total per Ton Milled.	Net Profit. Pr. lb. Copper	Pr. Ton Milled	§Dividends.	Stoping per Fathom.	Drifting per Foot	Sinking per Foot.
	$	tons.	lbs.	%	cts.	$	cts.	cts.	cts	cts	cts	cts	cts	cts.	$	cts.	cts.	$	$	$	$
1873	897	51,048	863,368	.82	26.6	220,631	361	20.6	148	125	1.4	3.0	86	49.0	8.26	−23.3	−394	..	22.28	19.09	19.78
1874	940	69,728	1,372,406	.98	22.3	302,737	166	17.8	66	99	2.2	.7	25	20.0	4.09	2.2	25	..	17.33	14.42	30.00
1875	974	80,000	1,531,531	.98	22.4	354,252	181	14.9	88	88	2.1	.7	43	20.0	3.90	2.4	50	..	17.74	13.50	36.00
1876	979	96,696	1,835,041	.95	21.4	385,252	164	14.2	86	67	2.3	.6	56	18.9	3.53	2.5	42	..	17.23	12.58	30.00
1877	980	105,780	2,054,304	.97	18.5	378,141	151	12.1	35	58	1.7	.6	12	15.8	3.06	2.7	50	..	16.24	11.83	36.10
1878	981	111,709	2,043,863	.92	16.2	322,593	127	8.3	45	49	1.8	.5	24	15.2	2.71	0.9	9	20	14.46	10.06	.....
1879	981	122,668	2,339,073	.95	16.3	392,592	123	7.3	21	42	1.6	.4	9	12.2	2.39	0.4	85	40	13.93	10.02	22.85
1880	981	169,825	2,341,145	.71	18.8	468.474	131	9.9	32	38	1.9	.4	14	16.3	2.26	2.5	35	40	14.35	12.90	18.04
1881	981	176.055	2,528,000	.72	17.1	428,982	76	5.6	40	43	1.8	.4	4	13.8	1.96	3.3	47	80	11.17	10.08	17.51
1882	981	189.800	2,634,675	.69	17.5	460,137	83	4.9	36	37	1.4	.4	5	13.8	1.90	3.7	51	80	10.65	10.05	15.57
1883	981	195,669	2,682,197	.69	15.0	398,793	73	7.1	28	35	1 8	.4	4	12.9	1.72	2.3	31	40	9.82	9.23	23.88
1884	981	209,510	3,163,585	.75	11.8	363,276	62	4.4	31	39	1.6	.3	7	10.9	1.64	0.9	9	20	8.74	8.20	25 50
1885	981	241,010	3,582,256	.74	11.2	402,304	58	4.8	20	30	1.4	.3	4	9.5	1.39	1.6	22	40	7.97	7.83	22.00
1886	981	247.035	3,503,670	.71	11.0	382,344	54	3.4	23	26	1.4	.3	1	9.6	1.35	1.5	20	40	4.74	4.82	22.94
1887	981	255,750	3,641,865	.71	12.1	452,278	68	3.8	18	27	1.3	.3	3	9.9	1.45	2.4	37	60	4.39	4.54	24 19
1888	981	298,055	3,974,972	.67	14.8	593,282	66	3.4	17	27	1.2	.3	7	10.0	1.36	4.7	62	80	4.31	4.73	24.19
1889	981	278.680	3,698,837	.66	12.1	453,816	69	3.9	10	28	1.2	.3	13	10.5	1.39	1.8	23	60	4.49	5.53	24.20
1890	981	278,300	3,619,972	.65	14.9	545,521	79	3.4	24	28	1.2	.3	11	11.8	1.55	3.1	40	40	4.21	5.10	22.90
1891	981	297,030	3,653,671	.62	12.6	461,649	76	3.9	19	26	1.2	.3	11	11.8	1.55	0.7	12	..	4.33	4.92	16.25

ALLOUEZ MINE.

‖ 1881	......	63,362	1,204,224	.95	18.1	227,962	216	11.7	18	65	2.3	0.8	10	19	3.67	−0.9	− 7	..	10.22	13.20	35.00
1882	......	97,232	1,683,557	.86	17.9	300,818	177	13 5	9	56	2.1	0.5	20	17	3.00	−0.9	− 8	..	9.46	12.78	26.93
1883	......	102,388	1,751,377	.89	15.1	265,066	155	10.4	14	52	2.0	0.4	22	15	2.73	−0.1	−14	..	6.48	9.84	14.36
1884	......	119,630	1,932,170	.80	13.0	251,673	133	5.9	8	50	1.9	0.3	35	14	2.34	−1	−23	..	6.02	8.54	13.00
1885	......	62,500	1,050,546	.84	11.0	115,855	97	7.3	8	44	2.3	0.3	2	11	1.94	.....	9	..	.....	.....	....
1886	......	116,612	1,725,463	.73	14.8	18,899	....	....	...	...	...	..	..	....	....	......	9	.	.....	.....	.....
1887	......	....	856,400	...	10.4	9,606	....	....	...	...	...	...	..	....	....	.....	.....	..	.....	.....	.....
1888	......	....	314,198	...	13.6	123,511	....	....	...	...	1.7	1.5	..	....	....	......	.....	..	4.87	8.06	....
1889	......	116,608	1,762,816	.75	12.1	213,019	1.13	5.2	5	42	1.4	0.4	6	13	2.04	−0.9	12	..	5.12	8.25	11.50
1890	......	97,020	1,407,828	.72	14.7	247,428	1.52	5.0	9	43	1.4	1.1	20	14	2.41	0.7	− 7	..	5.36	8.22	11.10
1891	......	96,164	1,241,423	.64	12.0	227,309	1.39	5.5	4	44	1.5	1.4	6	13	2.35	−1	− 7	..	5.06	8.01	13.55

OSCEOLA MINE.

1886	1,250	137,725	3,560,786	1.3	10.5	374,144	126	16.0	14	15	1.9	0.3	11	8.6	2.24	1.8	49	...	9.42	6.55	12.49
1887	1,250	145,200	3,583,723	1.4	11.9	424,937	126	18.7	13	23	2.2	0.3	3	9.8	2.57	1.8	48	50	9.95	6.58	12.26
1888	1,250	183,036	4,134,320	1.1	15.0	621,275	130	21.1	13	34	2.5	0.2	12	11.6	2.02	3.5	77	150	11.19	6.59	18.54
1889	1,250	175,587	4,534,127	1.3	11.8	542,991	138	22.4	11	27	2.1	0.2	13	10	2.59	1.8	49	50	11.62	6.76	9.66
1890	1,250	183,825	5,294,792	1.4	15.6	828,994	144	28.9	12	33	2	0.1	41	11.2	3.23	4.4	127	225	11.75	7.11	15.33
1891	1,250	234,325	6,543,358	1.4	12.5	819,751	143	15.5	14	36	2.1	0.1	24	10.1	2.82	2.4	67	150	10.96	6.32	16.05

TAMARACK MINE.

a 1886	650	36,129	1,979,400	2.7	10	202,032	266	20.4	14	80	0.8	0.3	2.6	8.1	4.44	2	1.13	...	13 32	10.33	45.67
1887	650	90,587	4,636,521	2.6	10.2	474,615	209	18	12	77	0.8	0.3	1.8	8.2	4.21	2	1.03	...	13.01	10.65	24.86
1888	650	144,412	10,389,861	3.6	13.1	1,448,944	184	16.6	17	55	0.2	0.2	1.0	5.7	4.13	8.2	5.96	640	11.86	9.56	20.00
1889	650	169,250	11.036,469	3.3	12.1	1,430,119	206	18.8	19	48	0.1	0.1	.9	6.2	4.07	6.7	4.37	560	10.56	9.55	19.39
1890	650	155,250	8,928,249	3.9	11.9	1,073,111	219	17.7	18	39	0.2	0.1	2.3	7.2	4.17	4.7	2.73	670	10.87	9.18	16.00
1891	650	282,987	14,076,957	2.5	14	2,008,777	185	16.6	18	31	0.1	0.1	1.2	6.6	3.32	7.5	3.79	600	11.44	9.29	25.60
1892	650	338,700	16,805,360	2.5	11.3	1,920,694	192	17.3	18	32	0.1	0.1	2.3	6.6	3.26	4.8	2.38	400	10.88	8.89	27.00

ATLANTIC MINE—AVERAGE MONTHLY EARNINGS.

Year.	Contract Miners.	Whole Force.	Year.	Contract Miners.	Whole Force.	Year.	Contract Miners.	Whole Force.
	$	$		$	$		$	$
1881......... ...	52	46	1885.............	43	41	1889............	62	48
1882......	62	48	1886.......... ..	56	45	1890............	65	51
1883	63	49	1887.............	55	45	1891.....	63	51
1884............	50	45	1888.............	58	45			

* Mining includes all underground expenses. † Smelting includes freight. (*a*) Years ending June 30.

‡ Brokerage includes all office expenses, salaries, and taxes. § 1 = 1000.

‖ 1881, 10 months; 1885, January to May; 1888, November and December.

NOTE.—1885, after May, the mine was leased and remained so up to October 1888, inclusive.

— denotes loss.

per pound of ingot. Included in this smelting charge is also the freight on the mineral from the mill to the smelter. The thirteenth column, brokerage, includes expenses of the head office, salaries of company officials, taxes, insurance, etc. The fourteenth column shows "improvements;" that is, buildings, machinery, etc. The fifteenth and sixteenth columns give the total cost per pound of copper and per ton of ore milled. The seventeenth and eighteenth columns give the net profit per ton milled and per pound of ingot. The nineteenth column gives the dividends paid each year in thousands of dollars. The twentieth, twenty-first, and twenty-second columns give the average cost of stoping, drifting, and sinking, and are extremely instructive figures, for they show very clearly the influence of improved appliances, such as rock-drills and high explosives, and the general facilities in doing work which have from time to time been introduced.

At the Atlantic the cost of stoping has been reduced from nearly $18 per fathom (omitting the exceptional figure of $22.28 in 1873) to about $4.33 in 1891, and drifting per foot from $14.42 to $4.92. The introduction of rock-drills and high explosives was not at once a great economy; but as experience was gained, and as the contract miners made higher wages by their use, the economy became more and more apparent and affected not alone the cost of breaking ground per foot or per fathom, but, through the rapidity with which ground was opened and could be broken, the extent of openings required for a given output was reduced and the work in every department was pushed with a degree of energy heretofore unknown.

It would be absolutely impossible to attain the great output of to-day by the old methods of work, no matter how many men were employed. The general conduct of the work in and about the mines has undergone a progress scarcely less important than that shown in drifting and stoping. More work per man per day is accomplished through the greater facilities provided for doing it, and through the high-pressure energy infused in every department by the example of one where men strive to earn extra-high wages by the use of improved appliances.

In shaft-sinking, so much depends on the amount of water met with, it has not been possible to show the same decrease in cost, but in the total cost per ton mined and in the several items which comprise it the progress is shown clearly in these tables. Space does not permit of a full discussion of these extremely valuable figures, but they will nevertheless prove, in the influence they will exert among mining men in every part of the world, one of the most valuable contributions ever made to the technology of the industry.

The great reduction in the cost of work has been accompanied by a practical increase in the remuneration of the workmen. The accompanying table (p. 137) shows that the actual earnings of the men have increased, and it is well known that all the expenses of living have very greatly declined within the period under review. This is therefore equivalent to a further advance in wages. These tables again demonstrate that low cost of production is due to increased skill and knowledge and economy in administration far more than to reductions in wages. In fact, it is generally accompanied by a marked betterment in the condition of labor. There are, we believe, no other mines in the world, however low their daily rate of wages may be, that do mining or milling work at as low a cost as is done with high wages in the United States.

CENTRAL MINE.

(Tons of 2240 lbs.)

Year.	§Capital Paid in.	Stamped.	Copper Produced	Yield, per cent.	Sell'g Price pr. Lb	Total Receipts.	Cost.									Net Profit.		§Dividends.	Stoping per Fathom.	Drifting per Foot	Sinking per Foot.
							*Min'g pr. Tn.	Haul'g to Mill	Surface Exp.	Stamp'g pr. Tn.	†Smelt'g per Lb.	‡Brok'ge pr. Lb.	Impvt. pr. Tn.	Total per Lb. Ingot.	Total per Ton Milled.	Pr. lb. Copper	Pr. Ton Milled				
	$	tons.	lbs.	%	cts.	$	cts	cts.		cts	cts	cts	cts	cts.	$	cts.	$	$	$	$	$
1859	47	......	241,622	....	22.6	73,595	...	...	....	...	...	...	...	....	.....	....	.....	...	17.66	6.73	13.05
1860	79	......	114,197	....	21.9	25,102	...	....	....	...	...	...	...	....	.....	....	.....	...	19.15	7.13	13.28
1861	96	......	248,742	....	20.4	50,877	...	....	....	...	...	...	...	....	.....	....	.....	...	15.95	7.32	15.16
1862	100	7,514	484,764	....	26.7	129,556	276	...	....	...	...	...	...	....	.....	....	.....	...	16.25	7.84	17.22
1863	100	9,946	619,268	....	33.1	205,022	273	...	....	...	...	...	...	....	.....	....	.....	50	20.07	9.58	21.83
1864	100	.. ..	901,292	....	47.9	433,195	...	....	....	...	...	...	...	....	.....	....	.....	50	24.16	13.85	22.53
1865	100	17,552	1,099,242	3.13	32.8	370,544	163	20.8	.	27	2.3	2.5	21	29.4	18.37	3.3	2.01	50	26.69	13.13	21.27
1866	100	19,702	1,333,036	3.39	29.9	417,337	163	21.1	....	11	1.8	1.7	218	23.3	17.01	6.0	4.16	50	22.41	11.84	25.13
1867	100	17,064	1,244,441	3.64	24.8	310,924	128	19.2	....	93	1.9	1.3	47	20.9	15.24	4.0	8.49	50	20.20	11.68	22.54
1868	100	15,232	1,800,943	5.88	24.0	434,326	172	22.0	....	101	1.9	1.3	93	16.9	20.01	7.0	8.49	40	18.88	11.13	26.37
1869	100	17,688	1,807,801	5.11	22.3	411,098	137	16.5	....	86	1.8	1.2	67	17.0	17.56	5.0	5.69	70	17.80	11.08	34.00
1870	100	18,380	1,327,156	3.62	20.4	278,927	175	15.4	....	81	1.8	1.4	60	17.0	12.77	3.0	2.41	80	17.58	11.00	27.24
1871	100	21,646	1,432,662	3.30	22.7	330,711	90	13.3	....	95	1.9	1.2	24	17.0	11.36	5.9	3.92	50	16.44	12.48	25.61
1872	100	18,942	1,244,349	3.02	30.4	386,566	110	14.9	....	98	1.9	1.6	193	17.0	11.48	13.0	8.92	80	18.83	13.16	24.86
1873	100	15,903	1,503,117	4.72	29.0	442,637	131	20.2	....	122	2.8	1.3	117	18.1	17.62	10.7	10.21	160	21.49	13.44	32.12
1874	100	15,668	1,740,603	5.54	20.8	366.208	144	18.0	....	107	2.0	1.1	154	14.7	16.46	6.0	6.90	160	17.09	11.31	30.47
1875	100	17,118	1,466,952	4.28	22.6	373,634	134	15.1	....	86	2.5	1.2	303	15.9	13.62	6.0	5.38	80	18.95	12.07	32.88
1876	100	12,658	2,161,400	8.54	20.9	451,218	145	16.0	....	102	2.1	1.2	176	12.1	22.12	8.0	11.45	140	19.65	16.23	32.84
1877	100	14,119	1,995,609	7.06	18.3	368,644	154	15.0	..	82	1.9	0.9	84	13.3	18.65	5.0	7.45	100	18.61	11.53	33.60
1878	100	13,858	1,891,013	6.82	15.8	301,212	115	12.5	....	69	1.8	0.7	34	11.0	15.32	4.0	5.98	80	17.29	10.55	32.22
1879	100	12,478	1,799,495	7.21	15.5	288,914	119	10.6	....	64	1.8	0.4	36	11.0	16.09	4.0	7.05	100	18.57	11.26	35.23
1880	100	14,520	2,026,078	6.97	18.2	362,976	140	11.2	....	72	1.8	0.4	121	12.0	16.53	6 0	8.46	60	18.38	12.78	27.58
1881	100	20,549	1,418,465	3.45	17.1	249,635	81	10.2	....	70	1.9	0.5	...	14.0	9.87	3.0	2.31	120	16.23	11.84	29.81
1882	100	18,639	1,353,597	3.63	17.5	230,776	83	11.6	....	88	1.9	0.6	. .	14.0	10.29	3.0	2.09	60	15.26	10.50	28.97
1883	100	18,146	1,268,556	3.49	15.0	195,675	87	11.1	....	77	1.9	0.5	...	14.0	10.45	1.0	0.32	40	14.82	9.23	26.39
1884	100	18,146	1,446,747	3.98	11.8	186,843	67	11.1	....	85	1.4	0.5	...	10.9	10.14	1.0	0.15	30	12.78	8.59	24.97
1885	100	17,812	2,157,408	6.05	11.1	240,961	78	9.8	....	74	1.3	0.4	...	9.0	10.69	2.0	3.15	40	12.07	9.00	19.88
1886	100	......	2,512,886	....	10.6	269,626	...	. ..	....	...	1.7	0.1	...	8.6	.....	2.0	. ...	40	13.74	9.02	20.26
1887	100	......	1,923,277	....	12.1	237,386	...	....	....	...	1.7	0.2	...	10.1	.....	2.0	.....	40	12.85	6.93	23.48
1888	100	. ....	1,817,023	....	14.9	274,202	...	....	....	...	1.7	0.1	...	10.9	.....	4.0	.....	70	13.44	7.46	20.25
1889	100	......	1,270,592	...	12.6	165,520	...	.. .	....	...	1.7	0.1	...	10.6	.....	2.0	.....	20	13.25	7.75	17.80
1890	100	......	1,413,391	....	14.9	216,472	...	....	....	...	1.7	0.1	...	13.6	.....	1.3	.....	20	13.08	7.80	28.12
1891	100	......	1,313,197	..	12.0	159,621	...	....	....	..	1.6	0.1	...	14.8	.....	–2.7	.....	...	13.10	6.35	17.94

QUINCY MINE.

Year.	§Capital Paid in.	Stamped.	Copper Produced	Yield, per cent.	Sell'g Price pr. Lb	Total Receipts.	Cost.									Net Profit.		§ Dividends.	Stoping per Fathom.	Drifting per Foot	Sinking per Foot.
							*Min'g pr. Tn.	Haul'g to Mill	Surface Exp.	Stamp'g pr. Tn.	†Smelt'g per Lb.	‡Brok'ge pr. Lb.	Impvt. pr. Tn.	Total per Lb. Ingot.	Total per Ton Milled.	Pr. lb. Copper	Pr. Ton Milled				
	$	tons.	lbs.	%	cts.	$	cts	cts.	cts	cts	cts	cts	cts	cts.	$	cts.	$	$	$	$	$
1866	200	49,903	2,114,220	2.11	31.1	661,107	602	23.3	125	167	1.9	1.8	46	28.9	12.20	2.3	1.03	...	22.40	15.74	27.39
1867	200	37,774	1,831,448	2.42	23.8	437,482	493	10.9	83	168	2.6	0.6	29	19.8	9.63	4.0	1.92	60	19.74	14.46	28.36
1868	200	36,554	1,461,000	1.99	24.6	357,078	459	17.7	54	128	1.7	1.4	46	22.4	8.68	2.2	1.82	...	19.43	12.93	24.94
1869	200	59.767	2,460,635	2.05	21.8	529,082	372	13.1	25	107	1.6	0.8	9	16.4	10.09	5.4	2.09	40	18.91	13.24	25.04
1870	200	55,027	2,572.980	2.33	21.0	538,170	367	13.1	34	116	1.8	0.8	7	14.5	6.95	5.5	2.82	120	17.96	13.48	31.99
1871	200	59,757	2,338,882	1.95	23.5	549,730	351	11.9	22	101	1.6	0.7	6	15.6	6.11	7.9	3.08	140	18.44	13.00	28.22
1872	200	60.828	2,276,308	1.87	32.3	725,097	466	13.3	28	106	1.6	0 9	115	22.9	8.58	9.4	2.82	350	20.81	17.36	36.62
1873	200	63,272	2,800,005	2.21	26.5	722,408	468	11.7	30	121	1.6	0.7	56	18.7	8.20	7.8	3.20	100	21.36	16.16	34.00
1874	200	67,200	3,046,698	2.26	21.8	656,083	371	13.5	49	109	1.6	0.6	17	15.2	6.86	6.6	2.90	160	20.15	14.67	30.27
1875	200	70,501	2,892,617	2.16	22.1	653,168	370	7.5	41	97	1.7	0.7	21	15.8	6.48	6.4	96	220	19.73	14.01	35.12
1876	200	74,195	2,949,863	1.92	20.0	581,227	365	9.8	32	91	1.7	0.7	4	15.5	8.20	5.0	91	160	18.83	12.92	36.00
1877	200	75,307	2,720,558	1.80	16.0	506.058	304	6.5	26	95	1.2	0.7	29	12.3	5.30	3.9	94	80	17.29	11.22	34.00
1878	200	....	2,991,950	...	....	447,510	...	....	...	...	...	...	...	10.3	.....	.....	.....	40	....	.....	.....
1879	200	......	2,639,958	....	....	445,506	...	....	...	...	...	...	...	9.7	....	....	....	220	.....	.....	.....
1880	200	....	3,696,263	....	...	755,695	...	...	...	...	...	...	...	9.7	....	.....	.....	320	.....	.....	.....
1881	200	98,869	5,702,606	2.88	18.0	1,038,457	...	....	...	...	...	...	...	10.0	5.78	8.0	4.71	440	.....	.....	.....
1882	200	101,327	5,682,663	2.79	17.0	973,506	...	....	...	...	...	...	...	9.5	5.34	7.5	4.25	440	.....	.....	.....
1883	200	97,100	5,549,087	2.85	14.0	830,783	...	....	...	...	...	...	...	9.7	5.56	4.3	2.99	320	.....	.....	.....
1884	200	99,196	5,680,087	2.86	12.2	695,999	...	....	...	...	...	...	...	8.5	4.92	3.6	2.09	200	. ....	.....	.....
1885	200	108,181	5,848,530	2.75	12.1	668,516	...	....	...	...	...	...	...	7.4	4.05	4.7	2.12	240	.....	.....	.....
1886	200	109,702	5,923,519	2.76	10.8	643,642	...	....	...	...	...	...	...	7.4	3.99	3.4	1.05	240	.....	.....	.....
1887	200	94,250	5,609,762	2.97	11.8	662,155	...	....	...	...	...	...	...	8.6	5.14	3.2	1.88	200	.....	.....	.....
1888	200	117,514	6,367,809	2.71	16.7	1,018,488	...	....	...	...	...	...	...	10.9	5.47	5.8	3.19	400	.....	.....	.....
1889	200	117,785	6,405,686	2.72	11.9	768,440	...	....	...	...	...	...	...	9.3	5.09	2.6	1.43	200	.....	.....	.....
1890	200	165,140	8,064,253	2.04	15.4	1,242,269	...	....	...	...	...	...	...	8.2	4.00	7.2	3.51	400	.....	.....	.....
1891	200	263,678	10.542.519	2.50	12.6	1,357,474	...	....	...	...	...	...	...	9.1	3.69	3.5	1.49	450	.....	.....	.....

* Mining includes all underground expenses. † Smelting includes freight.

‡ Brokerage includes all office expenses, salaries, and taxes. § 1 = 1000.

CALUMET AND HECLA COPPER MINING COMPANY.*

Year.	Capital Actually Paid in.	Real Estate.		Personal Estate.		Debts.	Credits.	Ore Milled, Short Tons.	Yield. %	Lbs. of Ingot Produced.	Average Prices Per Lb.	Estimated Receipts.	Dividends.	Estimated Costs.†		
		Amount Invested.	Increase Yearly.	Amount Invested.	Increase Yearly.									Total.	Per Ton Milled.	Per Lb. Ingot.
	$	$	$	$	$	$	$				Cents.	$	$	$	$	Cents.
1867..	303,360	36,704	....	167,683	....	312,000	220,000	....	....	1,351,173	f24.27	631,290	....	723,290	....	g53.5
1868..	800,000	180,007	143,303	a455,327	287,644	668,413	400,081	....	....	b5,098,375	24.33	1,737,075	....	2,005,407	....	g39.3
1869..	"	381,744	201,737	729,912	274,585	1,247,912	1,272,127	....	....	c12,315,771	22.12	2,724,249	100,000	2,331,702	....	19.0
1870..	"	677,468	295,724	832,326	102,414	592,027	1,193,102	....	....	14,061,584	20.74	2,916,373	500,000	1,839,471	....	13.1
1871..	1,200,000	894,378	216,910	870,009	37,683	597,932	1,501,423	....	....	16,222,590	23.08	4,144,174	1,250,000	2,591,755	....	g16.0
1872..	"	962,768	68,390	926,185	56,176	214,158	2,007,790	....	....	16,183,836	31.38	5,078,488	2,400,000	1,782,071	....	11.0
1873..	"	1,048,094	85,326	1,126,600	200,415	484,441	2,350,948	....	....	18,848,265	27.39	5,162,539	2,000,000	3,089,665	....	16.4
1874..	"	1,190,323	142,229	1,457,166	330,566	173,228	2,692,881	....	....	20,125,225	22.08	4,443,650	1,600,000	2,190,504	....	10.9
1875..	"	1,330,505	140,182	1,521,756	64,590	257,465	2,481,582	249,704	4.30	21,473,954	22 60	4,853,114	1,600,000	3,548,650	14.21	16.5
1876..	"	1,406,302	75,797	1,482,692	− 39,064	161,123	2,010,471	259,935	4.17	d21,690,737	20.70	4,489,983	1,600,000	3,261,752	12.56	15.1
1877..	"	1,541,732	135,430	1,564,961	82,269	150,225	2,763,191	247,935	4.55	22,568,468	17.90	4,039,756	1,600,000	1,693,297	6.83	7.5
1878..	"	1,614,964	73,232	1,594,035	29,074	180,076	2,648,119	271,000	4.66	25,251,128	15.84	3,999,779	1,600,000	2,544,702	9.39	10.1
1879..	"	1,756,314	141,350	1,741,562	147,527	462,682	3,877,354	284,715	4.61	26,271,243	16.90	4,439,840	1,600,000	1,893,211	6.65	7.2
1880..	"	2,064,357	308,043	2,076,965	335,403	661,412	4,071,698	334,343	4.75	31,675,239	18.71	5,926,437	2,500,000	3,430,823	10.26	10.8
1881..	"	2,262,112	197,755	2,367,953	290,988	157,725	3,837,043	340,080	4.61	31,360,781	17.87	5,604,172	2,000,000	3,335,140	9.81	10.6
1882..	"	4,086,170	e1,824,058	2,614,369	276,416	352,850	2,445,549	344,132	4.59	32,053,540	17.58	5,635,012	2,000,000	5,221,631	15.17	16.3
1883..	"	4,388,128	301,958	2,942,990	298,621	785,600	2,604,129	372,570	4.45	33,125,045	15.00	4,968,757	2,000,000	3,242,927	8.70	7.8
1884..	"	4,573,748	185,620	3,127,324	184,334	530,556	2,470,862	435,352	4.63	40,473,585	12 52	5,067,293	800,000	4,145,516	9.52	10.2
1885..	"	4,772,505	198,757	3,279,615	152,291	493,853	2,469,878	535,820	4.40	47,247,990	11.16	5,272,876	1,700,000	3,745,048	6.99	7.9
1886..	"	4,651,575	− 120,930	3,103,150	− 176,465	781,901	2,629,792	598,522	4.22	50,518,220	11.25	5,683,300	1,500,000	4,311,434	7.20	8.5
1887..	"	5,044,755	393,180	3,670,324	567,174	559,772	2,513,681	654,055	3 52	46,016,123	12.08	5,558,748	1,000,000	4,452,730	6.81	9.7
1888..	"	4,979,031	− 65,724	4,023,581	353,257	736,267	2,292,905	763,728	3.29	50,295,720	14.87	7,478,974	2,000,000	5,876,245	7.70	11.7
1889..	"	5,282,116	303,085	4,426,924	403,343	995,398	2,421,193	807,918	3.01	48,668,296	12.31	5,991,067	2,000,000	4,121,910	5.10	8.5
1890..	"	5,626,387	344,271	4,954,976	528,052	1,411,454	4,083,224	i947,700	3.16	59,868,106	14.73	8,818,572	2,000,000	5,602,597	5.91	9.4
1891..	"	5,432,927	− 193,460	5,128,658	173,682	1,557,866	4,193,809	h960,309	3.31	63,586,620	13.14	8,355,282	2,000,000	6,361,109	6.62	10.0

* The Calumet and Hecla mines were operated separately by the Calumet and Hecla companies from 1867 to 1870, inclusive, but their reports for these years have here been combined.

† The estimated receipts and costs are based upon the receipts from copper and increase in capital only, and include improvement account as given in real and personal estate columns. The Hecla and Torch Lake Railroad transports the Calumet and Hecla ore from the mines to the mill at Lake Linden, six miles from Hecla and seven miles from the farthest shaft. From *Poor's Manual* it would appear that the cost of transporting ore was on the average 10.2c. per ton in 1887 and 9.4c. per ton in 1890.

a Including Hecla and Torch Lake Railroad.

b For 18 months ending Dec. 31, 1868.

c For 12 months ending Dec. 31, 1869.

d From 1867 to 1872, inclusive, the respective reports are for the year ending July 1. From 1873 to 1875, inclusive, the reports are given up to the first of May. In accordance with an act of the Legislature, the form of the report, as well as its date, was changed, the latter being the 31st of December of each year instead of the company's fiscal year. Owing to this change the year 1876 is carried to Dec. 31 and covers 20 months.

e Includes $1,250,000 expended for the Fine Lands.

f These prices were obtained by averaging the prices actually realized by the following companies, and they assume that the Calumet and Hecla Company received for its copper as much as the average of other companies: From 1867–72, inclusive, by the Central and the Quincy; in 1873 by the Central, Quincy, and Atlantic; from 1874–77, inclusive, by these and the Osceola; and since 1877 the figure is the average amount received for copper sold by from five to ten of the Lake companies.

g Capital paid in is here charged to cost.

h This figure represents the tons transported from mine to mill over the Torch Lake Railroad.

i Estimated from best available data.

Calumet and Hecla.—In pursuing this investigation into the cost of Lake copper it was essential to ascertain, as closely as the meager statements of the company permit, the cost of production by the Calumet and Hecla—usually accounted the cheapest producer in the world. This company makes no proper report to its stockholders, who will be much interested and possibly surprised at the results of our investigation.

The law of Michigan obliged each company, previous to 1876, to make sworn statements each year of (1) the amount of capital actually paid in; (2) the amount invested in real estate; (3) amount of personal estate; (4) amount of debts as near as could be ascertained ; (5) amount of credits as near as could be ascertained; (6) amount of copper obtained.

From 1876 forward these statements are given under the following heads :

1. Amount of cash paid in on the capital stock. 2. Amount of capital paid in by the conveyance of property to the corporation. 3. Entire amount invested in real estate. 4. Amount of personal estate. 5. Amount of unsecured or floating debt of the corporation as near as may be. 6. Amount of secured or bonded debt. 7. Amount due the corporation. 8. Amount of copper obtained.

These official statements are given in the accompanying table. We have also the amount of dividends paid, as they have from time to time been published, and the amount of ore milled each year, as given in the report of the State Inspector of Mines.

As the company never informs its stockholders or the public what its receipts have been, we have assumed, as an entirely fair and reasonable basis for estimate, that the Calumet and Hecla received for its copper (the most highly esteemed brand in the market) the average price actually realized by neighboring mines, as explained in the foot-note to the table. We have neglected any other receipts, such as from supplies, interest, rents, etc., which constitute a more or less important item in the accounts of other companies. From this single and fair assumption we have calculated the column of estimated receipts, and, deducting from these the dividends paid and any net increase in credits, we get a sum which represents expenditures or costs, including as "costs" investments under the headings "real and personal estate." These two items appear to cover only buildings and machinery and the like, except in 1882, when $1,250,000 was paid for lands purchased. There does not appear from these statements to have been any depreciation account, the total amount of investment in both real and personal estate steadily increasing from year to year at the rate of from about $300,000 to $900,000, except in a few instances where the decrease is indicated by a minus (—) sign, and they now stand as an asset in the enormous amount of $10,561,585. There is nothing in the brief statements of the company to indicate what the present actual value of these "assets" is, but should the same policy be continued, it is evident that by the time the mine would be exhausted—when, as every one knows, neither the personal nor the real estate would have any measurable value—these apparent "assets" would reach magnificent figures. We prefer in this, as in each of the other cases analyzed in these tables, to count all expenditures for personal or real estate (except where new mining property is purchased) as a proper charge against the metal produced each year. There are then no

illusions as to the cost of production, and investors have an opportunity to measure the degree of economy or extravagance with which their property is managed.

The "credits" of the company are made up, in part, of copper on hand and unsold, and which is taken at an arbitrary valuation each year. This accounts in a measure for the great fluctuation in their amounts, and through them in the "estimated costs." It would be very much more satisfactory to make this analysis from specific official itemized reports of receipts and expenditures, but these are not obtainable, and the importance of the investigation induces us to make it as we have done, with every desire to be absolutely impartial and altogether disinterested.

Even with these extravagant costs it appears that this wonderful mine has always made large profits, and could do so even at the lowest mark that the copper market ever reached. It is evident that if it were managed with the economy practiced at any of the other mines given in these tables, the saving would amount to an enormous sum each year.

If the Calumet and Hecla worked at the same cost as the adjoining mine (Tamarack), which mines the same ore body at a total cost of \$3.32 per ton of ore, it would have saved just about half its total "estimated cost," \$6.62 per ton, or, say, \$3,180,000 in 1891; or, in other words, it could have paid the same dividends it did in 1891 (165% on the capital invested) and have sold its copper at 5c. per lb.; or, selling at 13.14c. per lb., it could have paid about 432% dividends. Had this mine attained the cost figures of the Quincy (\$3.69 per ton), its copper would have cost it but 5.6c. per lb.; while if it should get to a cost even 50% higher than the Atlantic, that is to say, equal to \$2.33 per ton, its copper would have cost about 3½c. per lb., and its dividends would have risen correspondingly. The question of the economy or extravagance of the management is one which concerns primarily the stockholders, but the entire copper industry is interested in knowing at what figure this great mine could, under economical administration, put copper on the market.

The Quincy mine has been enormously profitable. With a capital paid in of only \$200,000, it has for many years paid regularly from \$200,000 to \$450,000 in dividends each year; that is, from 100% to 225% a year. Its reports, which some years ago were given in great detail, no longer furnish the information necessary to complete our table. They do, however, enable us to give the total cost per ton of ore and per pound of copper. From these tables it appears that Quincy is, next to Tamarack, the cheapest producer of copper in Michigan or in this country, if not in the world. The figures are instructive and suggestive.

The Old Dominion Copper Company of Arizona is also a very cheap producer. In 1892 its total cost of pig-copper (96% copper), including every expense, such as improvement account, taxes, etc., was only 6.82c. per lb. at the smelter, or, adding freights to New York (1.25c.), its total cost would be 8.07c. per lb. This low figure was due partly to the high grade of the ore, which yielded 11.62% copper, and partly to the low consumption of fuel (coke), which was 13.64% of the whole burden and 17.09% of the ore smelted.

Coke is extremely high priced at Globe, Ariz., but when the railroads bring it in it will be possible to reduce these figures of cost materially.

In future volumes of this work many other figures of cost will be given.

American Methods of Ore Sampling and Assaying Copper.

By Albert R. Ledoux, Ph.D.

It is well known that up to 1888 no large contracts had ever been made in which the sale of argentiferous copper matte and settlement for the same were based entirely on American terms, when Mr. W. A. Clark of Montana and Messrs. James Lewis & Son of Liverpool contracted to deliver and receive, respectively, several thousand tons on final settlement in New York. Since that time many thousand tons have been disposed of both in Great Britain and on the Continent on the same terms, notably during the years of the late "French Copper Syndicate." After the collapse of this, and the consequent glut of furnace material, European buyers were able to dictate their own terms very largely, and settlements were again based on European assays and weights. But an erroneous impression prevails in the United States as to the reasons influencing British smelters in insisting upon the methods practiced there. It is not because they consider these uniformly more fair to the buyers than to the sellers of material, nor is it because they consider the results more scientifically accurate; but this, like so many other things in the older countries, is the result of tradition, which, once crystallized into business methods, it is exceedingly difficult to change. One of the best known copper smelters of Swansea said to the writer: "You Americans do not realize what you are asking when you wish us to purchase on the electrolytic assay and take delivery in America. Take my works, for example. For over 100 years we have been basing all our buying, all our furnace-work, and all our expectations upon the Cornish assay. All our furnace charges are calculated upon the same basis. This system permeates our whole business to the core—from the ticketings in the market to the refinery work."

Americans should remember one thing—that the Cornish assayer does not pretend that his assay represents the percentage of copper in the sample submitted to him. He does not even claim that the figures he gets represent the copper contents, but simply the "produce;" and it is well understood in England that he means by "produce" not simply how much copper there is in the ore or other material, as does the American assayer in his return, but what in his opinion, based on experimental fire-work, the smelter can get out. It is for this reason that there is such a variation not only between the American electrolytic method and the Cornish assay, but between Cornish assayers themselves working on the same sample of ore.

The year 1892 is memorable for far-reaching and important alterations in the business. A year or two ago Mr. Haggin announced that thereafter Anaconda matte would be sold only at a fixed price per pound of fine copper, thus simplifying calculations and doing away with "return charges" and various other complications not well understood on this side of the water. But this year the Anaconda Company took a still more radical step, and announced that after its present contracts were completed, if it should again export furnace material it would be only upon American assays and weights, the settlement being for cash against these returns, free on board at New York or Baltimore. It is gratifying to state that, immediately upon this determination becoming known, offers

were promptly forthcoming from large English and German metal-houses which were willing to accede to these terms, and Messrs. Vivian & Son have announced again through their agents in New York that they are prepared to buy on American sampling. This is the condition of things at this writing; and, in answer to many inquiries from abroad, the writer has prepared, at the request of the *Engineering and Mining Journal,* the following statement of American methods of sampling and assay, in order that European smelters may have a clear idea of American practice, and also have some data upon which to base their calculations in bidding.

SAMPLING.

When mining and metallurgy became established in America sufficiently to develop an American type, it was noticeable, as in other branches of industry, that mechanical appliances took the place of hand-labor wherever possible. This arose principally from the scarcity of labor in a new country. The chief difference, therefore, between American and European methods of sampling lies in the nearly universal employment of hand-labor in the old countries and the general use of sampling-machines in America.

There are still smelting-works on this side of the water which employ hand-labor in sampling, but there are no public sampling-works of any reputation where an automatic device of some kind is not used. The public sampler, whose business and reputation depend on the accuracy of his work, cannot afford to stake everything on the integrity and judgment of his employees alone. In fact, effort at judgment and extreme conscientiousness are among the worst qualities in a successful hand sampler. If he attempts to pick out his sample and to take just the right proportion of fine and coarse, mineral and gangue, rich and poor, he will be certain to err in judgment: the ideal hand sampler is the man who succeeds best in making a machine of himself.

The automatic devices that are employed in the United States may be divided into two classes—those which divert a portion of a falling stream of ore either continuously or intermittently, and those which divert the whole stream at regular intervals of time. An ideal automatic sampler should be able to divide accurately not only pulverized ore, but any material that may pass the crusher jaws, whether it be lumps of ore or frozen concentrates; whether clean or mixed with iron scrap, chips, waste, etc.

In all automatic sampling-works the first consideration is the quantity to be taken, and in this respect practice varies somewhat in different localities. Whenever ore is sampled, from whatever mine or deposit, the whole lot should be put through the crusher and the sampling machinery to insure a thorough mixing and an accurate sample. This is also true—in fact, more so—of concentrates, which, though they do not require crushing, do require the most careful and persistent mixing, and there is no better method of mixing them than to put them through a machine. In the case of plain copper mattes, however, such as the non-argentiferous Anaconda and Boston-Montana, where the material varies slightly from month to month in composition, and where, as in most cases, it has been crushed and bagged at the smelter, it is not necessary always to put the whole material through, for an actual sample may be taken by crushing fine and sampling down

one third or even one fifth of the lot. But when this is done the sampler must check his work very frequently by taking two or more samples from a lot. Especially is this important where carelessness at the smelter allows the shipment in the same car, or in the same lot, of more than one grade of matte.

In the early days of matte production in Montana it was common to find reverberatory matte and blast-furnace matte shipped in the same car. Such a practice renders it necessary for the sampler to put through the whole lot; as otherwise, even if he succeeds in selecting a fair sample, the next sampler who has to review his work may obtain different results, happening to get hold of a larger or smaller number of the higher or lower grade of bags. The same custom holds good, of course, for shipments in bulk, where the one third or one fifth to be crushed must be selected from all parts of the lot by some mechanical rule, as by taking so many shovelsful so many feet apart at certain definite points.

It is the American practice, at least on the Atlantic seaboard, to take a separate sample from every car, thus reducing to a minimum the loss if there are errors through inaccurate sampling or in calculation of results.

While the method just outlined is sufficiently accurate for all ordinary copper mattes, it will not suffice for argentiferous mattes, especially those produced by lead smelters. In such mattes, unless the sampler is sure that they have already been thoroughly crushed and intimately mixed, it is his practice and his duty to sample the whole lot. Only in the case of uniform product from one furnace, with which he is thoroughly acquainted, and by regular checking by duplicate or triplicate samplings, can he afford to take less than the whole lot.

It will be seen that I do not include under the head of mechanical sampling any of the devices, such as the split shovel, intended only to assist hand-labor. Nor am I considering here the methods which must be employed in sampling ores on the dump or in the mine, which of course necessitate an entirely different mode of procedure, but I confine myself to treating of the practice in an ore sampling-works where the material is on the way to market and is assumed to be in merchantable condition.

Some of the sampling-works at great smelting centers in the West are very elaborate, and, being exceedingly accurate in their returns, they have the confidence of both miner and buyer. In some of them, to avoid possibility of interference, interested parties are allowed to watch the sampling from a glass cage in the center of the building, from which they can see the progress of the operation, but cannot get access to the samples.

It is more customary in the Eastern States to have the sampler represent both parties, and his results are accepted by both. All these sampling-works contain a crusher, usually Blake's, through which the ore is passed for the purpose of reducing it to reasonable uniformity in size, or at least to break up the larger lumps. From the crusher it is raised to an automatic sampling-device, where the most important part of the operation commences. The older sampling-works employed various devices which diverted a portion of the material after it had been crushed, the simplest being a cone or dividing-box upon which the crusher discharged, and which automatically separated a third or a tenth of the crushed material into a pile by itself. Other devices of this class selected a portion of the falling stream, the crushed ore being elevated and dropped from a height. Some-

times a revolving arm passed through the stream; sometimes a wedge divided it. In other appliances the ordinary cone was used, but in all of these there was danger arising from the almost certain segregation of the particles. In every falling stream of ore, or when it is thrown by the bucket elevator, the heavy and coarse particles will tend toward one side or toward the center, and no device with which I am acquainted has as yet been invented which will accurately divide a falling stream, and working well on one size or grade of material will also work well on another of different character.

The most recent sampling-works, therefore, have adopted a form of sampler which diverts the entire stream during a given and definite interval of time. In the sampling-works with which the writer is connected two such machines are employed, giving equal satisfaction—the Brunton and the Constant. They can be so adjusted that the crushed ore, elevated to a chute immediately above the sampling-machine, descends upon it, and during say ten seconds the descending stream is diverted to the right, and during say twenty seconds it is diverted to the left, so that whatever passes during the first ten seconds, whether it be fine or coarse, rich or poor, light or heavy, is all deflected to a set of Cornish rolls. There it is pulverized and is again raised to a second sampling-device, which again automatically diverts one third, now one ninth of the original lot, the discarded two thirds in each case returning to the sampling-floor, where it is bagged and returned to the car. The moisture sample is taken from the discarded two thirds at the time when the material is weighed into the car before proceeding on its journey. The sample, now representing say one ninth of the original lot, which has passed the rolls, is returned to the floor, where upon an iron-covered platform it is mixed together by hand and divided down by quartering, which must be the ultimate termination of all sampling. But there is no selection in this quartering, and it is always proceeded with by the same rule and in the same manner.

The sampling of copper bars may be dismissed with a single word. It is performed just as in Europe—by boring say every fifth bar twice, half way through on opposite sides. In sampling argentiferous bars of variable composition every bar is bored twice. If they carry gold also in any quantity (and always in the case of anodes), the borings are melted and granulated, or recast into a sample bar which is again bored. These are the only ways to secure uniformity in the laboratory sample and assays.

ASSAYING.

Uniformity in determination of copper in furnace material in America dates from 1882, when, at a meeting of the American Institute of Mining Engineers, Mr. W. E. C. Eustis pointed out the fact that the principal public analysts employed many methods, and that this lack of uniformity in method gave a corresponding lack of uniformity in results. It is safe to say that at the present day no such great variation on identical samples could be found in the profession. Gradually the cyanide, Swedish, and other methods have been abandoned for the electrolytic in all public laboratories, and in our large cities the Edison electric current can be employed in the laboratory for precipitation. This electrolytic process is as accurate and uniform in its results as a scientific method possibly can

be, and dealers in furnace material, who a few years ago were satisfied to split a difference of one per cent, are now holding the assayers to a strict accountability if on the same sample there is a variation of over two tenths. The advantage of the Edison current is its constancy, whereas the battery-jars being variable, the force decreases steadily from the beginning to the end of the operation. With a device for adding outside resistance when but a few determinations are on, and decreasing it proportionately with a number, no chemical method can be more consistent and satisfactory.

It is not my purpose to describe at length the details of the electrolytic method for copper determination, as it is quite simple and is accurately described in all the books.

Silver is determined by scorification assay. The only departure from the usual English practice is that we combine the wet and dry methods. The copper is first separated by solution, the lead and silver present being precipitated, collected, and scorified. This method is frequently employed when making duplicate or check assays. But the all-scorification method is usually practiced. It is evident that inaccurate sampling and careless methods will produce discordant results in America, as anywhere else, and it is only between reliable sampling-works (of which there are many) that uniformity is to be expected. There is quite as much difference between the results at some mines and smelting centers and at the public sampling-works as between the American and English ore yards. By only a few of the Western producers is any pretense made to take a perfectly accurate sample, the managers being content with a sample and assay that will give them an idea of how their works are running, knowing that the sale will be based upon the more careful sample taken at the public works, whose business it is to be accurate. As examples of annoying variations, I append the following returns for weight and assay on ore and matte from a Western copper mine where no sampling-plant existed, compared with those upon which settlement was made in accordance with Eastern sampling:

No. of Cars.	Mine Wt.	Final Wt.	Difference.	Mine Assay.	Final Assay.
34	821,173	811,206	1.21%	48.26%	46.27%
51	1,179,336	1,151,226	2.37	49.21	50.10
17	428,601	418,397	2.36	59.39	56.39
27	629,033	624,007	0.79	58.83	54.73
29	680,316	678,965	0.19	54.18	53.04
43	951,466	956,706	0.54	59.30	57.58
45	963,597	969,772	0.63	56.46	54 41
52	1,611,648	1,598,207	0.83	64.59	63.24
Average difference against mine (on basis of exact weights)........			0.78	56.28	54.47

The difference in average assays was 1.81% copper.

These figures are taken from shipments in 1890. In 1891 44 car-loads from the same mine showed average mine assay 59.18%; average final assay, 60.82%. In this case the final assay was higher. The average loss in weight was 0.80%. Most of this ore was shipped in bulk and considerable of it transferred *en route*. It may be said here that the difference in weight is not necessarily due to lack of accuracy. Even when matte is shipped in bags it will lose in weight when trans-

ferred "lake and rail," or from one car to another, especially when bags are torn by hooks in handling.

The following comparative returns are selected from among the July and December shipments by a mining company working nearly a thousand miles from the location where the ore and matte in the above table were derived. This material was shipped in bags and represents more careful sampling and assaying in the West. There are two statements for each year from 1889 to 1892, inclusive, the months of December and July being chosen as types.

No. of Cars.	Mine Wt.	Final Wt.	Difference.	Mine Assay.	Final Assay.
20	774,277	773,256	0.13%	54.92%	54.83%
20	805,821	804,552	0.15	57.49	58.03
10	402,779	402,644	0.03	55.97	55 33
10	403,458	404,146	0.17	55.97	56.20
10	420,886	420,178	0.16	51.50	51 80
10	402,302	401,706	0.14	55.66	56.05
10	403,604	403,963	0.08	55.21	54.26
10	421,260	420,892	0.08	55.04	55.47
Average difference (on basis of exact weights).........			0.07	55.22	55.25

The difference in weight (0.07%) is against the mine, but the equally slight difference in assay (0.03%) in copper is in favor of the mine.

I have hitherto given comparative figures for weight and copper assay, as between sellers and sampling-works. I now add a table of comparative silver assays in such of the mattes in the last table as were argentiferous:

Mine Assay.	Final Assay.	Difference.	Average Difference.
53.20 oz.	52.90 oz.	0.30 oz.	(against mine) 0.35 oz. per ton.
53.60 "	53.26 "	0.34 "	
56.48 "	57.08 "	0.64 "	
22.29 "	22.92 "	0.63 "	
54.53 "	52.20 "	2.33 "	

The loss in silver—that is, the difference between the mine assay and the final assay—in a year's shipments from an Arizona property covering a great many car-loads was 1.80 oz. per ton of 2000 lbs.

While the averages do not display any glaring discrepancies, individual differences on single car-loads, where careful sampling was not resorted to in the West, have been very great, amounting to over 7% in some instances. But when the sampling and assaying are carefully conducted, there should be no such discrepancy. I am indebted to the Pennsylvania Salt Manufacturing Company for the comparative assays on copper matte and bars between a New York sampling-works and its assayer at Natrona. On 88 car-loads the maximum difference in any case was 0.94% in copper, the average difference on the 88 lots being 0.03% of copper and 0.08 oz. of silver per ton of 2000 lbs.

In 111 car-loads of copper matte sampled at a public sampling-works in New York and delivered to a smelting-works on the Atlantic coast, the maximum difference between any two returns was 0.73%, the average difference being 0.07%.

A prominent smelter has kindly given me these figures of a year's actual experience of assays and weights, calculating the results in out-turn:

Yield.	On A.'s Assays.	On B.'s Assays.
Copper, lbs.	6,305,154	6,311,499
Silver, oz.	351,271	348,019
Gold, oz.	2,106	2,297

Number of samples assayed, 400.

$$\left.\begin{array}{l}\text{A. loses in copper, } \tfrac{1}{10}\%,\\ \text{A. loses in gold, } \tfrac{4}{10}\text{ oz.,}\\ \text{B. loses in silver, } \tfrac{9}{10}\text{ oz.,}\end{array}\right\}\text{Average.}$$

Calculating the metals in the form in which they were combined at the following values, we find the net difference $162.05, viz.:

3,252 oz. silver at 80c.		$2,601.60
6,345 lb. copper at 9c.	$571.05	
101 oz. gold at $18.50	1868.50	
		2,439.55
		$162.05

I come now to the most important part of this communication—the one, in fact, which has caused it to be written: how the results compare between the Cornish assays and English weights on the one hand, and our American assays and weights on the other.

The American system of sampling and assaying has been sufficiently outlined. A word at this point will make plain the chief difference in the systems of weighing in the two countries. In the United States the public samplers—at least those in the East—employ "sworn weighers," who have gone before a notary public and taken a sort of oath of office that they will faithfully and honestly perform the duties of a public weigher.

Ore in bulk is weighed on platform scales, in barrows or small wagons holding from 500 to 1500 lbs. The exact weight registered is recorded and no allowance made for odd pounds. The weight is not taken at a level beam, however, but on a rising beam, which practically amounts to an allowance of from one eighth to one fourth pound per load. Ore or matte in bags is always, where practicable, weighed on a beam scales, the system being the same as with materials in bulk. From 6 to 10 bags are taken for a draft. No returns are ever based on car-load weights on track scales. The settlement is always based on the actual weight, ascertained as above, with no allowance for draftage, etc., and upon the actual percentage of copper found, less the arbitrary deduction of 1.3 unit of fine copper. This arbitrary deduction is the result of agreement between the copper smelters and producers of the United States, and is supposed to represent the average loss in smelting. In refining bars there is, of course, no such loss as 1.3 unit, and the buyer or smelter is the gainer, while in leady mattes or in base ores there may be considerably more loss than 1.3. In America the smelter protects himself in the price he bids or in the refining toll he charges, instead of asking the assayer to find out for him, in each case, what his loss is likely to be—which is what the Cornish assay attempts to do.

I am indebted to the Liverpool Copper Wharf Company, Limited, for the fol-

lowing table representing its experience with some 2500 tons of matte from America:

ORDINARY COPPER MATTE.

Shipping Weight.	Landing Weight.	Loss, Per Cent.
1355 4 0 8	1354 18 1 17	0.2

Difference between American assay, after deducting 1.30 unit, and Cornish assay, 0.88% copper, more or less.

ARGENTIFEROUS MATTE.

Shipping Weight.	Landing Weight.	Loss, Per Cent.
1139 8 1 22	1130 19 1 13	0.75

Difference between American assay, after deducting 1.30 unit, and Cornish assay, 1.79% copper, more or less.
Difference between American assay and English assay for silver, 0.30 oz., per ton of 2240 lbs.

These figures are about what others have found in their experience.

From the above table it would seem that British buyers purchasing in the United States, free on board at New York, and selling again at English terms, should make an average allowance of about fourpence per unit. It is my opinion that this average difference will be found sufficiently covered by this allowance. But it is only fair to add that much greater variations than these in weight and assay sometimes occur between returns from different sampling-works in Great Britain and America. I am furnished with the following statement of losses for three months in 1892 by exporters of leady and other argentiferous mattes, as the result of their experience with material that was weighed and sampled here, and afterward at different points and at different times in England and Wales: Average loss in weight, 2%; average loss in copper, 1.75%; average loss in silver, 3 oz. per ton.

I am indebted to these exporters for the above statement, and to other firms and companies for the preceding tables. Such losses as indicated in the last case in weight and silver assay would be almost prohibitory if they represented the average experience of the trade.

Considerable of the loss in weight can be avoided if matte is shipped in barrels instead of in bags. This is the invariable custom with some European buyers of material on this side. Strong, empty kerosene barrels can be purchased for about 85c. to-day, and will hold 1000 lbs. each, so that the excess of cost over bags would hardly be more than 50c. per ton. Empty glucose barrels are sometimes employed, but the inside is always sticky, and on this account there is difficulty in extracting all the matte on arrival at destination.

The data I have given will make plain the difference in method and results in the two countries, and serve as a basis of calculation for buyer and seller. The next great change in the furnace material market is already in sight. The year 1894, if not 1893, will see an end of the exports of ore or matte from America, and those smelters who rely upon this source of supply must realize this fact.

The Bessemerizing of Copper Matte.

By Charles Wade Stickney, M.E.

In 1883 Monsieur Pierre Manhés, of Lyons, France, filed applications in the United States Patent Office for a process (and certain modifications of it) for converting copper matte of low grade into white metal, and a further conversion of this product into pig copper. Upon two of these applications patents covering the fundamental points were granted in 1892. Shortly after the filing of the patent applications, an experimental plant was erected and operated by pupils of Manhés, under license, at the Parrot Company's Copper Works at Butte, Mont. The experiment was entirely successful, under the efficient direction of Mr. A. J. Schumacher, who was at that time, and for several years afterwards, the superintendent and metallurgist of the works; and the process has developed into a very practical and profitable method of converting a matte containing 50 per cent copper into a pig product containing about 99 per cent copper, and generally from one third to one half of 1 per cent of gold and silver—in fact, all that was in the matte.

In carrying out the process, the appliances used were in general those of a Bessemer converting plant, from which the name of this process was derived; but in metallurgical reactions and results this process bears but a faint resemblance to the real Bessemer process of making steel. In addition to the original plant set up under Mr. Schumacher's superintendence, certain unessential improvements in minor details of machinery have lately been added by the management. The most practical of these improvements were made by Mr. James Breen, successor to Mr. Schumacher. A description of the variations will be found following the description of the general process.

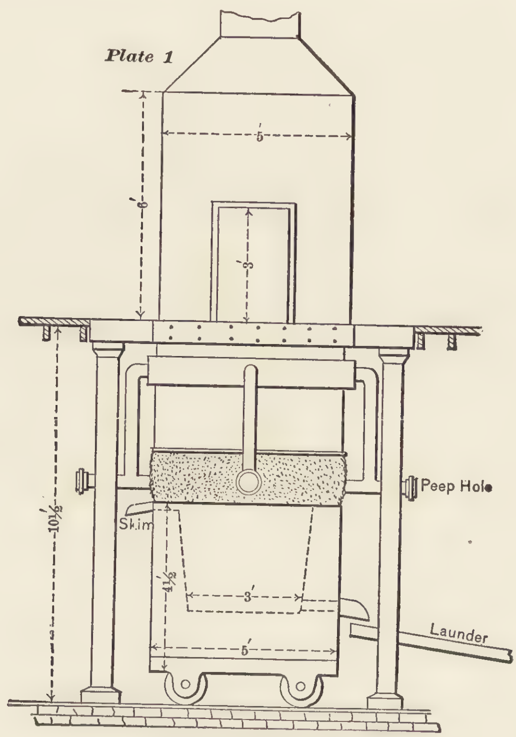
The American patents granted to Monsieur Manhés, March 8, 1892, are based on the following fundamental claims: "Charging the matte, in a molten condition, into a converter, forcing jets of air through the molten matte and maintaining it in a molten condition and at the proper temperature by the combustion of the sulphur and iron in the matte, continuing the operation until the sulphur and iron have been separated from the metallic copper;" "a converter for reducing pig copper from copper matte, having a wind belt encircling the converter above its bottom, a series of tuyères extending through the lining of the converter and communicating at the outer ends with the wind belt, and removable stoppers located in the outer wall of the wind belt and in alignment with each of said tuyères, whereby a drift-bar may be inserted successively through said tuyeres to remove obstructions."

In the following pages the writer gives the technical and practical details of the process as at present practiced in this country, together with some suggestions of his own, which aim at making the process easier and less expensive.

The matte produced by the smelters of Butte, as it comes from the blast-furnaces, is never of so low a grade in copper as to require two operations for the production of the pig, but the grade is crowded well up to the limit allowed by the two opposing factors—fusibility and economy of fuel: the higher grades being obtained only by a greater fuel consumption. An average run is, roughly speaking, a mono-sulphide of iron mixed with a sub-sulphide of copper, and is of

about the following composition: 51 per cent copper, 22 per cent iron, 26 per cent sulphur; the copper often running as low as 48 per cent and as high as 55 per cent. A small percentage of iron is often replaced by small quantities of zinc, lead, antimony, and arsenic, which elements are partly volatilized in the converter and partly enter the slag.

When the matte has become cold enough to handle, it is broken up by sledges to about the size of a man's fist, and elevated in cars to a high track leading above the mouth of the remelting furnace. This furnace (Plate 1) consists of a



Remelting Furnace.

simple cupola shaft, the main body of which is supported upon four hollow pillars of cast-iron, and terminates below in a detachable well made of boiler iron, lined deeply with a mixture of crushed quartz and fire-clay, the exact composition of which is given hereafter. The lining is pounded hard in the well to a thickness of about 12 inches, and somewhat deeper in the bottom. The cupola shaft is also lined with the same material as the well, but decreasing in thickness above, and running out entirely near the feed-door. The well is placed on wheels for convenience in running it out on the iron floor, when it is necessary every few weeks to reline it. Tuyères enter the shaft just above the well, and they have peep-holes, through which the workmen can observe the level of the molten matte. The junction between the cupola shaft and the well is made by a heavy wall of the lining material, and this is often broken through by the fire, as the iron of the melting matte is very prone to eat it out. When this occurs

the cupola man in charge quickly patches it up from the outside, with lumps of lining composition which he keeps in readiness. At its rim the well is provided with a heavy cast-iron lip, by means of which the well is skimmed from time to time, as the level of the metallic bath rises above it. The whole furnace is so placed that the tap-hole at the bottom of the well shall be about two feet higher than the mouths of the converters when they are turned to a horizontal position. Two men manage the remelting furnace, one below and one above.

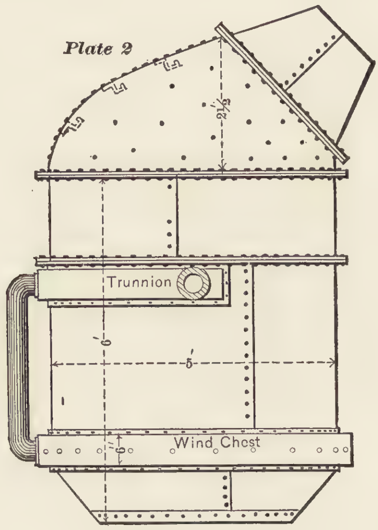
Cold matte is fed into the shaft above by the upper cupola man, who judges from experience how much coke and lime to mix with it. No charges are weighed out, but the coke used runs from 10 to 12 per cent of the weight of the matte, an amount somewhat above that required for smelting copper ore in the blast-furnace, which is due to the fact that the temperature of the matte, as it enters the converters, must be much higher than is required for fluidity only, otherwise the long run in the launder and the cold blast of air are apt to chill the charge around the converter tuyères and prolong the operation. Economy of fuel results in a waste of time. It frequently happens, too, that the cupola men get a full well of molten matte a considerable time before a converter is ready for charging, and some waste of fuel is unavoidable in this period of waiting. The proper management of the remelting requires more skill than any other part of the process. The quantity of lime charged is very small; it may be said, approximately, to amount to about one quarter of one per cent of the matte. Its object is to give fluidity to the skimmings of the well.

The melted matte, passing below the tuyères, settles in the well to a depth of about 30 inches, and the lower cupola man, by regulating the blast, keeps it on a level with the lip before mentioned, from which he draws off, from time to time, a thin stream of slag. This slag contains 4 or 5 per cent copper, and is returned to the blast-furnace, where it is mixed with other charges and plays the part of a flux while giving up its copper. The action of this furnace is regulated by the amount of heat produced by the blast, which is under control of the lower cupola man; the upper man merely keeps the shaft full of material, and gives more coke when the lower man wants more heat. One furnace of 5 feet outside diameter will melt about 30 tons matte per day, and will supply molten matte for three converters.

A launder of wrought-iron of semicircular section, 12 inches in diameter, lined with fire-clay and quartz (converter lining), is used to run the matte from the tap-hole of the well into the converters. It is supported from a swinging crane by chain tackle, which allows a quick adjustment in height to the converter mouths.

The converters are swung on trunnions, as shown in Plate 2, one of which communicates with a wind-chest which encircles the converter near the bottom, and through it an air-blast enters. The converter is made in three sections, of three-sixteenths wrought-iron boiler-plate, riveted. The upper section—the hood—is provided on the inside with numerous pieces of wrought-iron, riveted on, curved outward, and crooked at the outer ends, which afford a hold for the lining, which is put on around them while plastic. The wind-chest has five-eighth-inch holes drilled from the outside through its outer shell, and thence straight on through the side of the converter. The outer hole is kept closed by a wooden

plug which is easily removable, so that the inner tuyère hole can be kept clear from copper incrustation by thrusting an iron rod through the hole into the interior of the converter. The mouth of the converter is about one quarter the outside diameter of the body, and, when in position, points up into an opening in a brick gallery, which communicates with a dust-chamber and stack. A worm-screw operated by power takes into a cog-wheel of 20 inches diameter, which is attached to one trunnion of the converter, and can be worked



Original Parrot Converter
3/16" Boiler Iron
Stationary

in either direction by either of two pulleys placed on each side of a loose pulley. It is necessary to have the floor all around the converters formed of iron plates, because of the occasional spitting of matte from the converters, and the slopping over of slag or copper, in pouring and wheeling. On iron the hot liquid quickly chills, and does not adhere to the plates, and for this reason can be quickly shoveled aside.

Suppose, to begin with, that the converter shows that its lining is eaten out dangerously near the iron shell. The first business is to cool it. For this purpose it is allowed to rest until the red heat has disappeared, and then water is very cautiously introduced through a rubber hose; after a time the whole interior is filled with water, which overflows, runs over the exterior, and escapes through a trap and drain under the iron floor. When the converter is cool enough the water is emptied out, and a man goes inside who removes all loose lining and copper nuggets with a pick, or with hammer and gad. The converter is then turned mouth down and emptied. Frequently more than one half the old lining remains undisturbed, and the new lining is placed over it. The lining is composed of ground quartz (98 to 100 per cent silica), with sufficient fire-clay mixed with it to make it stick together. It is found that less than 15 per cent

of best fire-clay does not satisfactorily keep the lining in its place. The grinding is done in a revolving quartz-pan with stationary rollers, and the mixing by a machine similar to an old-fashioned clay-mixer for making brick. The composition of the lining in the bottom and sides of the converter, and in the converter hood, is as follows: For converter bottom and sides, crushed quartz, 99 per cent silica, coarse and fine, twenty parts by bulk; best fire-clay, three parts by bulk. For converter hood, fine crushed quartz, 99 per cent silica, six parts by bulk; best fire-clay, one part. For the remelting furnace and well, and for the launder, the same as for the converter bottom and sides. This lining is meant to wear away; in fact, the process depends upon the union of its silica with the oxide of iron. The linings last generally about eight hours. When the converters are running, one is cooling while the second is drying out and being heated up, and the third is in full blast, producing metal. In each shift of 12 hours, the lining of the three converters is performed by one liner and his helper. When the lining of one is completed, a ladleful of hot slag is poured in, an armful of wood is thrown on it, and on top of this two or three bushels of coke. A gentle blast is turned on through the tuyère holes, the lining dries out and afterwards gets red-hot, and the converter is ready for charging.

A man then shifts the belt, so that the converter turns on its trunnions through an angle of 90 degrees, until its mouth points toward and a little below the tap-hole of the remelting furnace-well. The launder is swung into place, and lowered by the chain tackle until its free end is thrust into the converter mouth. A helper to the lower cupola man holds an iron rod, one inch in diameter and five feet long, at the tap-hole, while the cupola man drives it with a sledge. This is sometimes quite a task, as the accumulation of chilled metal around the tap-hole may require the rod to be driven in two feet before the liquid metal is reached. When the rod slips in easily, on reaching the liquid metal, the helper hooks a close-fitting iron on the rod close to a knob at its outer end, and a reverse blow of the sledge jerks the rod out, the helper landing it out of the way by means of the hook iron. The molten matte then spurts out with great energy, under the pressure of about six pounds to the square inch. It is allowed to run along the launder into the converter for about ten minutes, that is, until about two tons have entered. As the converter begins to fill, a light blast is turned on to keep up the heat. At a signal to shut off, the cupola man places a sheet-iron shield over the launder so as to cover it for a distance of four or five feet from the tap-hole downward, in order to protect himself from the intense heat to which he is exposed while plugging the hole. The plugging is done in the usual way by placing a pyramid of fire-clay on a disc upon the end of a rod and thrusting it into the tap-hole. The launder is then swung out of the way, the air is turned on full blast, and the converter is brought upright with its mouth pointing into the opening in the dust-gallery. A dense cloud of sulphurous acid and other gases pours out of the mouth of the converter with a noise like a heavy waterfall. The air-blast enters under an initial pressure of 8 to 12 pounds per square inch (the higher pressure being more desirable). It is produced by a compound direct-acting pumping-blower of the Corliss type, made at the Reliance Works, Milwaukee.

From this stage onward no fuel is used, the heat being supplied by the com-

bustion of the sulphur in the matte. It sometimes happens, however, either from the initial temperature being too low, or from there being too small a charge, that the combustion of the sulphur fails to keep up the heat toward the end, and in this case a stick of wood is thrown in.

The air enters the mass about six inches above the bottom of the lining. Its first action is to replace the sulphur in combination with iron by oxygen, and to oxidize this sulphur to sulphurous acid gas. This double reaction is shown in the equation $2FeS + 3O_2 = 2FeO + 2SO_2$. The iron oxide is brought toward the sides by the action of the currents of air, where it comes in contact with the incandescent quartz lining, and combines with it to form a bisilicate of iron, which floats as a top layer. This action is shown in the equation $FeO + SiO_2 = FeSiO_3$. The composition of the slag thus formed varies considerably with different charges. It sometimes shows a few per cent more SiO_2 than Fe, as indicated by the formula, but it usually contains rather more per cent of iron than silica, thus showing that there is a small amount of the unisilicate formed. There are also small percentages of the silicates of lime and alumina.

This stage of the process is characterized by dense white clouds, tinged with rose and green. The rose tint first disappears and the white gradually diminishes, while the green becomes more constant. Finally, the close of this stage is indicated by both the white and green changing to a pale blue. When this change has become permanent it indicates that the iron is entirely combined with the silica.

The blast is now shut off, the slag-pots are run under, and the converter turned over. While the slag is poured off in a thin stream the skimmer tests the stream by rasping it with a long skimming-rod, which causes the fluid to spatter in all directions. When the behavior of the fluid exhibits the characteristic jump of white metal, thus showing that some of this is escaping with the slag, the skimmer orders the converter up a few inches, and after lightly skimming the charge, he turns on the blast, and orders the converter straight up as before. Before the converter gets up to its old position, all the white metal obtained from the slag-pots and the scraps of copper swept up from the floor are thrown into the charge. Each of the slag-pots which has just been filled is found to contain when cold a button of white metal near the bottom. These buttons are easily separated from the slag by a blow of the sledge, and are thrown into subsequent charges at the same stage of the process. The slag contains from three to five per cent copper, and it is sent back to the blast-furnace in company with the skimmings of the cupola-wells before described. The converter now contains nothing but white metal, as the iron, lime, and alumina have been slagged off, and the lead, zinc, arsenic, and antimony volatilized.

During all the period of blast, the wooden plugs in the wind-chest are extracted one after another, and the corresponding tuyère holes kept clear by rods, which are hammered into the converter. It is necessary to do this continuously on account of the rapidity with which noses of copper form over the tuyère holes, especially toward the close. After the blast has again been turned on, and the second stage commenced, a rather scanty blue flame, sometimes mixed with white, comes away from the converter. This color changes gradually. First the blue and white lessen and a rose color creeps in, until they disappear. The rose then

deepens to red and afterwards to reddish brown; at the same time its size gradually contracts until at the close only a thin, sharp tongue of flame is to be seen.

The precise moment when the sulphur is all gone and nothing but metallic copper left is hard to prescribe, as it is entirely a matter of experience. The color of the flame often varies in shade, and sometimes entirely disappears at the mouth. The changes from sulphide to copper, and again from copper to oxide, are so very slight in appearance that the whole charge may actually be oxidizing, and give no sign until the copper is too cold to pour. Such a mishap has sometimes occurred, and has created an enormous amount of work; in fact, if such an event happens when the converter is pretty well worn, it would seem most profitable to cut the rivets and take it to pieces.

If, when the flame shows the process to be nearing its close, the sparks which are projected against the plate on the further side of the dust-gallery are carefully watched, it will be seen that some of them stick to the plate, glow brightly, and instantly disappear, while others, of dull color, rebound from the plate like red-hot shot. When those which stick and glow become few, and those which rebound become numerous, it is time to pour.

If it be an object to get a very high per cent of copper, it is better to allow a small amount of oxide to form; but care must be taken that the charge remains hot enough to pour easily.

On turning down the converter the color of the interior will show to the experienced eye whether there is sufficient heat present in the mass. If the sulphur is not entirely gone, the surface will be smooth; but if any oxide has formed, it will be seen floating on top as a blebby mass. This cannot form so long as there is any sulphur remaining. In the pouring process the oxide is kept back by throwing a dam, composed of a few pieces of scrap copper from the floor, across the converter mouth. The copper flows out underneath this dam and the oxide is left inside the converter. This remaining oxide does no harm, and is not lost; for as soon as the new charge is put in, it is reduced back by the sulphur in the matte.

A great deal of copper and oxide adheres to the lining, so that when a converter is to be lined, the best practice is to wash it out by running into it as much matte as will fill a couple of slag-pots, turn on the blast a few minutes, and then turn out the whole charge into the pots. The clinging particles of copper and oxide are thus changed back into white metal, and as this readily pours, the old lining is left quite clean. This practice, however, is not followed when the converters are crowded with work and the blast-furnaces are not.

When the lining has become so eaten that a clean sweep is to be made of it, the entire mass is taken out and distributed among some of the blast-furnace charges. This is done because the copper, silver, and gold work into it for four or five inches, and would be otherwise lost.

When a converter is ready to pour, a series of removable molds arranged on a wheeled car are run under it, and four men, with long hooks, roll this truck forward or backward to catch the stream in the successive molds. As the copper shrinks very greatly in cooling, three or four molds are first filled, and then the frame is run back and the first filled up further, and so on, so that each may contain about 200 pounds of copper.

The molds are previously daubed with a clay mud to prevent the pigs from

sticking to them. A charge produces about a ton of metal. The time occupied varies very greatly with the grade of the matte, initial temperature and force of blast, but the average time, from filling to pouring, may be put at about two hours. With a low-grade matte, after slag has been formed, the converter is sometimes again filled up with matte to avoid having at the close too small a mass of metal to retain the heat. The pigs rapidly become coated with oxide as they cool, which gives them the name of black copper. The fragments are pounded off from the edges, and they are ready for shipment.

One ton of 51 per cent matte requires the following materials: Coke for remelting, 220 lbs.; coke for heating converter, 10 lbs.; silica, 666 lbs.; fire-clay, 111 lbs.; lime, 5 lbs.

A plant of three converters and one remelting furnace is capable of treating continuously 25 tons of 51 per cent matte per day, and, with good luck and good management, can be crowded up to 30 tons. There are two shifts of 12 hours each, and day and night shifts change men twice a month.

The labor required per shift is as follows: One foreman at $5, $5; two cupola men at $3.75, $7.50; one liner at $3.50, $3.50; one skimmer at $3.50, $3.50; 7 laborers at $3, $21; total, $40.50. This gives the cost per day of two shifts, $81. If six converters are run together with two remelting furnaces, the total cost of labor is somewhat diminished, as follows: Two foremen at $5, $10; 6 cupola men at $3.75, $22.50; three liners at $3.50, $10.50; four skimmers at $3.50, $14; 28 laborers at $3, $84; cost per day, $141.

If the capacity of six converters be crowded up to 60 tons per day, the force must be increased for both shifts, thus: Two foremen at $5, $10; eight cupola men at $3.75, $30; four liners at $3.50, $14; four skimmers at $3.50, $14; 36 laborers at $3, $108; cost per day, $176.

The second case gives the lowest price for labor per ton, but is only possible where the two remelting furnaces are so situated as to allow of one cupola man above attending to both. Laborers act as helpers to all skilled workmen, and shift about as needed, except a few who are assigned to definite duties.

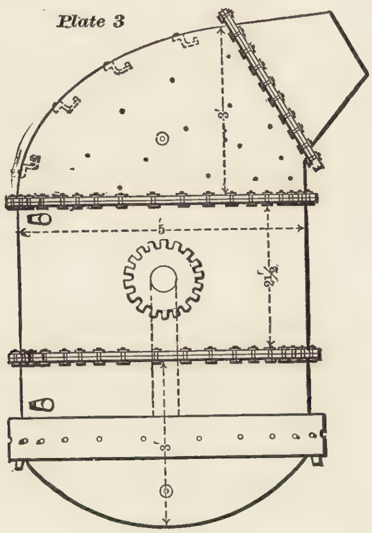
Cost of treatment per ton of matte at Butte: Labor, $2.93; fuel, $0.98; silica, and fire-clay, $1.84; blast, $0.90; total, $6.65. To this must be added interest on investment and on the expense account for 30 days, between shipment and marketing. At 10 per cent per annum this will amount to an additional 13 cents per ton. Repairs and renewal fund will add another 13 cents per ton, giving a total of $6.91 per ton of matte, or $13.55 per ton of copper, viz., about two thirds of a cent per pound of copper produced. The price of fuel is based on coke laid down at $8.50 per ton.

The cupola shaft has been water-jacketed: this is a very decided and obvious improvement, readily suggested by blast-furnace practice. The metal-well has also been water-jacketed; this is not so evident an improvement, because the matte, when sometimes kept a long time in the well, owing to some delay in the converters, gets chilled to a great depth about the tap-hole and bottom. The lining of the well, as before practiced, would seem to be the better plan.

Converters have been made of cast-iron, three-quarters of an inch thick, and in three sections, which are separable when bolts around the edges are removed. (See Plate 3.) These cast-iron converters are removable from their trunnions, and

are handled by a car and crane. When the lining is to be repaired the converter is removed by running a car under it. The car is provided with four adjustable platform-screws, which are screwed up until they impinge upon four projections cast upon the side of the converter. The trunnion-screws are then loosened and removed, and the converter is run out on a track, where a steam-crane picks it up and sets it on the floor. The three sections are then separated by unscrewing the bolts around the circumference, and the interior, thus exposed to the air, soon cools sufficiently for relining. Meanwhile, another extra converter, which has been previously relined, is put up in the place of the one just removed. This arrangement requires a double set of converters, one being worked while the other is being cooled, relined, and heated up again. The cooling is sometimes effected by a blast of cold air passed in through the trunnion, and the same blast

Plate 3



Improved Parrot Converter
3/4" Cast Iron
Removable & Separable

heats it up again when a fire is kindled inside. By means of the steam-crane the three parts are easily picked up and put together after relining. The arrangement for turning the converters consists of a rack-and-pinion wheel, the latter being attached to the trunnion, and the rack being moved by a piston in a water-cylinder. The water-pressure is furnished by a double plunger-pump and a hydraulic accumulator.

The use of a double set of converters, the preparation of one while its mate is running, the opening of the converter for relining, and the handling of it by a crane are great advantages, but they are partially offset by several disadvantages in the practical method of carrying out the idea. The use of cast-iron is of no advantage; on the contrary, it makes the converter heavy and unwieldy, and the great mass of metal absorbs a great quantity of heat, thus prolonging both the cooling and reheating operations. Again, the cast-iron cracks very soon in every

conceivable direction, and frequently two weeks' service will find several bolt-holes cracked out. Occasionally, however, one will be found to stand the wear very well. The work of separating the parts, seemingly so simple, is sometimes very arduous, for the reason that the lining bakes together at the junction, becomes continuous, and of a stone hardness. When the bolts are removed, the parts refuse to budge, and much time and hard work are consumed in prying the sections apart, to the frequent injury of the converter. The method of cooling by an air-blast is not so expeditious as that described below. Making the converter in three sections instead of two is worse than useless, for more time and strength are expended in separating the lower sections than are compensated for by any advantage gained, and hence it is rarely done. The two lower sections had better be in one and of a different shape, to facilitate the extraction of the old hard-baked lining,—the most serious work encountered in handling the process. Below will be found a suggestion upon this subject.

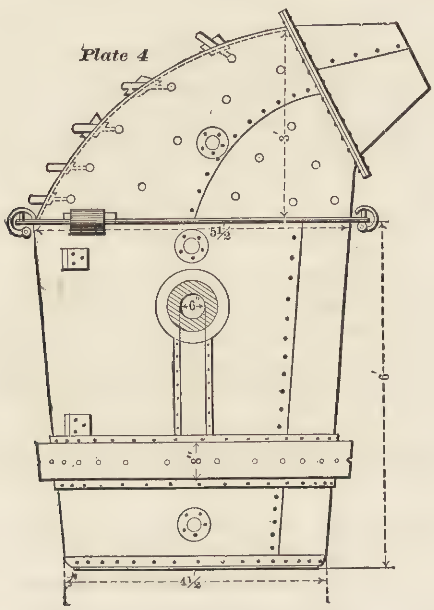
The writer believes that this process may be made more productive, at less expense, by certain changes in the machinery used, and in the method of handling it. The most obvious drawbacks at present are: (1) The waste of heat in cooling the matte and again remelting it; (2) the short life of the lining, with the attendant necessity of cooling the converter and heating it up again; (3) the length of time required to cool the converter; (4) the difficulty of separating the parts when held together by the hard-baked lining; and (5) the great amount of hard labor required to extract the old lining.

By arranging the blast-furnace on an elevation above the remelting furnace, the necessity of much handling of the matte will be avoided. In such a case the matte may be run into small molds the size of bricks, arranged in gangs on one base, and, as soon as they cool enough to set, they may be shot down an incline to a small iron bin, which has a small opening opposite and quite near to the feed-door of the remelting furnace. From this bin the cupola man will feed. The mass of matte will therefore enter this furnace at a little less than melting heat. If the blast is at any time producing more matte than is needed at the remelter, the overplus may be allowed to cool, and, being dumped into another bin, it may be used whenever the blast is producing less than the remelter requires. In this way a large amount of fuel, probably one third of that now used, may be saved. It must not, however, be forgotten that the temperature of the matte as it enters the converter must be considerably higher than when it leaves the blast-furnace, and hence the remelting furnace cannot be done away with.

The duration of the lining may be greatly prolonged by placing an iron hopper with an air-tight cover above the trunnion of the converter, forming a communication between the hopper and the blast-pipe by a vertical pipe entering the latter at a point near its entrance to the converter. The vertical pipe should have a gate easily closed and opened by the workmen below. The hopper may be filled with perfectly dry and powdered quartz, or with any powdered quartz ore which contains no metals except gold and silver. A very small percentage of copper might not be detrimental. By a judicious regulation of the supply turned into the blast-pipe, so that the quantity shall be slightly below the needs of the oxidizing iron in the matte, the lining will be called upon for but little silica, and its life will thus be very greatly prolonged.

The converters may be cooled very much more quickly than is possible by any present or past practice, so far as known to the writer. Air, at the ordinary temperature of the converter building, takes up heat very slowly, and water is a nuisance when used in bulk. The rapidity with which a cold-water mist takes up heat suggests its suitability here. By introducing a small air-blast pipe into a water-supply pipe near its extremity, and thrusting both through the trunnion into the hot converter, a fine cold mist will fill the interior, and, taking up heat rapidly, issue from the mouth as steam. By keeping the converter placed mouth downward when it gets too cold to produce steam, the water will run out, if any should form from the cold mist.

But a more expeditious method of handling this part of the process, obviating the cooling and picking out of the old linings, is to use a differently constructed converter, as illustrated in Plate 4. The converter is made entirely of three-



Stickney Improved Converter
3/16" Steel Plates
Removable, Separable, 2 Parts, Taper Body,
False Sides & Bottom, Removable Catch Pins.

sixteenths steel boiler-plate riveted; the body is made in one piece and the hood in another, these two parts being separable by driving out wedges from dogs on the outer rim. The main body tapers downward about an inch to the foot. A false bottom and sides are made in pieces of one-eighth-inch sheet-iron, somewhat similar to the head and staves of a barrel. The hood is made of the same material, but has no false lining. There are pins, however, near the lower edge of the hood, and at intervals over the inside (kept in place by a small shoulder inside, and by a wedge on the outside which fits into a slot in the part of the pin projecting through the converter shell), which take the place of the catches referred to in the description of the former construction, and hold the overhang-

ing roof of the converter in place. When it is desired to remove the lining the outside wedges can be quickly driven out, and the pins driven inward through the lining.

The lining is put in place in the following manner: The false bottom and sides are first polished with graphite and placed in position. The bottom is pounded hard with lining composition to a depth of 18 in. A kettle, which has been made of one-eighth-inch boiler-iron, 2½ feet diameter on the bottom, 4 feet high, expanding at a somewhat greater rate than the converter shell and perfectly smooth on the outside, with handles at the top, is set on the pounded quartz bottom exactly in the center of the converter, and the lining is then shoveled in and pounded hard around it. Afterward the kettle is lifted out by a crane, and a cavity is left in the center of a strong wall lining about 15 in. thick at the bottom and 12 in. at the top. This wall extends up flush with the top edge of the main body. The top of the wall all around is then sanded with fine dry sand. The hood, having its pins in place, is turned hollow side up, and is plastered with the lining composition to a depth of 12 in. at the edge, and gradually diminishing to 3 in. around the mouth. The hood is then picked up by the crane, turned upright, and placed on the body. The flanged edges are secured together by dogs and wedges, and, after being heated, the converter is picked up by the crane, landed on the carriage, and rolled to its place.

When relining is necessary, the converter is again landed on the floor, and the hood detached by knocking out the wedges, when the sanded junction in the wall will give a line of easy breakage. If sand is found not to answer, powdered graphite may be used. The crane lifts the hood and places it upright on an iron frame, three feet high and hollow beneath. The pin wedges are knocked out, and the pins driven inward through the lining with a heavy sledge. The lining is thus broken up and removed. It may be remarked, however, that the hood lining wears a long time, and its renewal is required much less often than that in the body. Its removal, however, is necessary when it builds up and chokes the converter.

The body is now seized by the crane, first turned on its side, then turned completely upside down, and suspended one or two inches from the floor. If the whole lining, with the false sides and the bottom together, does not drop out, a few taps on the sides will produce this result. The side and bottom pieces are easily detached separately by jarring, and then the whole lining may be picked up by the crane and placed in an iron mortar, to be broken up by a heavy chunk of iron being dropped on it. The unburned pieces may then be returned to the quartz pan for regrinding and mixing with new composition. The pieces badly coated and impregnated with copper should be sent to the blast-furnace.

The time and labor saved by this construction of converter and its manipulation can hardly be estimated by one who has not witnessed the daily struggles of workmen with hard-baked linings in the old styles of converters. By dumping the old lining while hot, no time need be lost in cooling by any system, as the thin steel shell may be sprayed and cooled sufficiently for relining in a very few minutes.

Thofehrn's Electrolytic Refining Process.

M. Hyppolyte Fontaine's work on Electrolysis describes M. Thofehrn's process for refining copper by electrolysis. In principle this does not differ materially from other electrolytic methods, but the arrangement of the parts and the general working out of the details makes it, in the opinion of M. Fontaine, a new, complete, and efficient system of copper refining.

In the plant at present in operation there are 120 baths in 12 series of 10 each. Each bath is a little lower than the next, and siphons are placed between them in order to obtain a constant circulation. After the electrolyte has left the last of each series it goes to a collecting basin from which it is pumped again to the distributing reservoir. The baths are made of concrete, lined first with wood which has been boiled in tar, and then with sheet lead. The surface of the concrete itself is protracted by a coat of a special kind of tar. The electrolyte consists of sulphate of copper, 150 parts; sulphuric acid, 60 parts; and water, 690 parts. In order to oxidize the electrolyte and so remove the impurities which are constantly forming, jets of air are introduced into the collecting basin and the distributing reservoir, and at the same time the liquid is kept at a temperature of 35° C.

The rate of production of refined copper is 1 gramme per ampere-hour, or in an average 2½ tons per day. The average drop in potential for each bath is .15 volt. The difference in potential at the binding posts of the dynamo is just sufficient to overcome the resistance of the bath and the conductors. A loss of 5% to 8% in the conductors is allowed. The section of the cable leading from the dynamo to the first vat should be such that the current shall not exceed 1 ampere per square millimetre. The anodes should be of such proportions that a current of 50 amperes should not be exceeded.

The cost of refining copper by this installation is $19.60 per ton. The original cost of the plant was $37,300; the stock in hand has always a value of $84,000, and the annual working expenses are $9,210. The interest on capital and stock and the depreciation amount to $8,130 per annum; this, together with the working expenses, is equal to $17,640. The production at 2½ tons a day is 900 tons a year, and $17,640 ÷ 900 = $19.60.

CORUNDUM AND EMERY.

Corundum is the hardest of the minerals which are abundant enough to be extensively employed as an abrasive material, and for this purpose it is extremely valuable. It has also been utilized as a source of aluminum in the electric-smelting processes. Emery has less hardness than pure corundum and is worth but about half as much. Garnet and other minerals of considerable hardness sometimes reduce the grade of the emery still further, and are guarded against in purchasing. The

usual test of quality is to compare a weighed sample with an equal amount of the standard grade, or of some well-recognized brand ; two weighed pieces of plate-glass of convenient size are then rubbed together with the sample between, and the process continued until the grit has disappeared and the plates no longer lose in weight from the abrasion. The amount of loss is a measure of the hardness and abrading power of the sample, the better grade giving, of course, the greater loss.

Corundum has been found in a large number of localities in the United States, but only three places have been actual producers. The vein or bed at Chester, Mass., was recognized as emery, in 1863, by C. T. Jackson, and has since furnished a large quantity of the mineral; but the chief American source at present is a belt of serpentine that extends from southwestern North Carolina into Georgia. It is an altered olivine rock, and has gneiss for its immediate associate, and along the contact of the two are found the veins (or beds) of decomposed rock which have the corundum disseminated through them. Corundum Hill, in North Carolina, and Laurel Creek, in Georgia, are the chief producers. The mineral is crushed, sifted, and washed, and thus comes to market in various sizes. Care is taken to avoid making undue amounts of the finest product, or flour, for this has less value than the coarser grades.

All the corundum consumed in the United States is of domestic production. The emery used comes chiefly from Asia Minor.

PRODUCTION OF CORUNDUM IN THE UNITED STATES.*

Year.	Short Tons.	Value.	Year.	Short Tons.	Value.	Year.	Short Tons.	Value.
1881........	500	$80,000	1885........	600	$108,000	1889........	2,245	$105,567
1882........	500	80,000	1886........	645	116,190	1890........	1,970	89,395
1883........	550	100,000	1887........	600	108,000	1891........	2,265	90,230
1884........	600	108,000	1888........	589	91,620	1892........	2,200	88,000

* From *Mineral Resources of the United States*, 1889 and 1890.

IMPORTS OF EMERY INTO THE UNITED STATES.

Year.*	Grains.		Ore or Rock.		Pulverized.		Other Value.	Total Value.
	Pounds.	Value.	Tons.	Value.	Pounds.	Value.		
1867...	......	......	448	$14,373	924,431	$38,131	......	$52,504
1868...	......	......	85	4,531	834,286	33,549	......	38,080
1869...	......	......	964	35,205	924,161	42,711	......	77,916
1870...	......	......	742	25,335	644,080	29,531	......	54,866
1871...	......	......	615	15,870	613,624	28,941	......	44,811
1872...	......	......	1,641	41,321	804,977	36,103	......	77,424
1873...	610,117	$20,706	755	26,065	343,828	15,041	$107	70,919
1874...	331,580	16,216	1,281	43,886	69,890	2,167	97	62,366
1875...	487,725	23,345	961	31,972	85,853	2,990	20	58,327
1876...	385,246	18,999	1,395	40,027	77,382	2,533	94	61,653
1877...	343,697	16,615	852	21,964	96,351	3,603	....	42,182
1878...	334,291	16,359	1,475	38,454	65,068	1,754	34	56,601
1879...	496,633	24,456	2,478	58,065	133,556	4,985	......	87,506
1880...	411,340	20,066	3,400	76,481	233,855	9,[illegible]02	145	105,894
1881...	454,790	22,101	2,884	67,781	177,174	7,497	53	97,432
1882...	520,214	25,314	2,765	69,432	117,008	3,708	241	98,695
1883...	474,105	22,767	2,447	59,282	93,010	3,172	269	85,490
1884...	143,267	5,802	4,145	121,719	513,161	21,181	188	148,890
1885...	228,329	9,886	2,445	55,368	194,314	8,789	757	74,800
1886...	161,297	6,910	3,782	88,925	365,947	24,952	851	121,638
1887...	367,239	14,290	2,078	45,033	†114,380	6,796	2.090	68,209
1888...	430,397	16,216	5,175	93.287	......	......	8,743	118,246
1889...	503,347	18,937	5,234	88,727	......	......	111,302	218,966
1890...	534,968	20,382	3,867	97,939	......	......	5,046	123,367
1891...	......	......	......	......	......	......	......	104,199
1892...	......	......	......	......	......	......	......	† 76,336

* Fiscal years ending June 30 until 1886; calendar years subsequently.

† Six months only; since classed with grains. † Six months.

CRYOLITE.

The sole source of this useful mineral at the present time is the mine at Ivigtût, in South Greenland, and all that is consumed in the United States is brought from that place. Some years ago it was reported that cryolite had been discovered in the Yellowstone Park, and small veins have been found at and near Pike's Peak, in Colorado; but these occurrences are only of interest mineralogically, and are of no economic importance.

The discovery and history of the cryolite mine in Greenland is described by Prof. G. Lunge in *Sulfuric Acid and Alkali,* who states that the mineral was first found at Ivigtût by a Danish whaler, who brought a piece of it to Copenhagen without stating whence it came. It was first described by Schumacher in 1795, and was analyzed by Abidjaard and Klaproth, its composition being determined subsequently by Vauquelin, Berzelius, and Deville.

Up to 1849 the mineral was found only in scientific collections, but in that year Prof. Julius Thomsen, at Copenhagen, proved it to be easily decomposable by lime both in the dry and in the wet way, and showed its applicability to the manufacture of soda. In 1854 he obtained an exclusive right for 30 years to mine cryolite and work it up in Denmark for soda and alumina, this concession being subsequently sold by him to a company, which erected a small factory at Copenhagen in 1857, and later a large one, still existing, at Oeresund. In 1861 and later, factories were erected at Harburg, Mannheim, Prague, Goldschmieden near Breslau, and Warsaw; but these works were obliged to discontinue the use of cryolite when the Pennsylvania Salt Manufacturing Company, with works at Natrona, Penn., obtained in 1865 the right to two thirds of all the mineral produced (*in maximo* 6000 tons per annum). From 1856, when the first whole cargoes were shipped, to 1873, about 68,000 tons of cryolite were got, the amount since 1865 being some 6000 or 7000 tons per annum.

Mr. Charles Hart has written an account of the cryolite mine at Ivigtût, published in the *Journal of Analytical and Applied Chemistry,* October, 1892, of which the following is an abstract:—

The cryolite mine of Greenland occurs in latitude 62° N., and is situated near the shore of the Arsuk Fiord, which is a body of water about one-and-a-half miles in width and navigable by the largest vessels, so that cargoes are loaded directly at the mines, which are about ten miles from the entrance to the fiord. The fiord is frozen from December until April, which prevents active operations

during the intervening months, though about 40 men are kept at the mines. The workmen are Danes, and every spring the steamer "Fox" brings enough men to swell the number to 250, bringing also food and other supplies needed. The steamer does tug duty for the freight vessels during the summer, and in the autumn returns to Denmark with a portion of the workmen. The ships, ten in number, engaged in this trade belong to Messrs. McKay & Dix of New York, and enter the United States at the port of Philadelphia. The time occupied in making the voyage to the mines and return is not less than two months and sometimes as much as seven months; it is a rare thing for a vessel to make two trips in a season, but the freight, 37s. 6d. per ton, is good, and there are no harbor dues in Greenland.

All the cryolite used in the United States is imported by the Pennsylvania Salt Manufacturing Company, and costs, delivered at Philadelphia, about $38.00 per ton. The Danish Government charges an export duty upon the mineral, which is computed and collected by its representative at the place of delivery. The contract calls for 10,000 tons annually, but this year the amount has been somewhat short of this on account of the ice. It is estimated that from 8000 to 9000 tons have been obtained annually for the last 28 years.

The entire product of the Ivigtût mine is under the control of a company in Copenhagen, although the Pennsylvania Salt Manufacturing Company controls the American trade, and the mining is entirely in charge of Danes, the methods in use being practically the same as when the mine was first worked. The mine is opened as a pit, which is now 87 ft. in diameter and has a circumference of 365 ft. It is 92 ft. from the shore of the fiord, and was first worked at a point but 4 ft. above tide-water. The pit has now reached a depth of 185 feet.

The stone broken in the mine is loaded on cars of 5 tons capacity, which are drawn up an incline by means of an endless chain. At the surface the mineral is assorted and piled in heaps between the mine and the shore. In preparing the mineral for shipment, the large masses of impurities, which amount in all to about 20% of the rock broken, are thrown away, and also the fine particles of the mineral, as only the large pieces are shipped. The contract requires that 90% of the material shipped shall be cryolite, and in bringing it to this state of purity about 2000 tons are lost annually.

The vein appears to widen with depth, but the quality of the mineral becomes inferior. In order to support the walls, pillars of cryolite 8 ft. in diameter are allowed to stand at intervals of 30 ft. When the mine is closed for the winter, salt water is run in from the Arsuk Fiord until the pit is filled to about one third its depth, so that it is necessary to unwater it at the beginning of operations every spring.

IMPORTS OF CRYOLITE INTO THE UNITED STATES SINCE 1871, IN TONS OF 2240 LBS.

Year.*	Amount.	Value.	Year.*	Amount.	Value.	Year.*	Amount.	Value.	Year.*	Amount.	Value.
1871...	....	$71,058	1877...	....	$126,692	1883...	6,508	$97,400	1889...	8,603	$115,158
1872...	....	75,195	1878...	....	105,884	1884...	7,390	106,029	1890...	7,129	95,405
1873...	....	84,226	1879.	....	66,042	1885...	8,275	110,750	1891...	8,296	76,350
1874...	....	28,118	1880...	....	91,366	1886...	8,230	110,152	1892...	8,155	73,847
1875...	....	70,472	1881...	.. ....	103,529	1887...	10,328	138,068			
1876..	....	103,530	1882. .	3,758	51,589	1888...	7,388	98,830			

* Prior to 1885 the imports are stated for fiscal years ending June 30; subsequently for calendar years.

FELDSPAR.

Orthoclase, of a composition K_2O, Al_2O_3, $6SiO_2$, is the principal feldspar mined. It occurs mingled with quartz and mica and much smaller amounts of certain rare minerals, and forms veins and feldspathic segregations in granites, syenites, and crystalline schists. It is not certain whether these deposits are intruded igneous dikes, or deposited from solution like veins. Probably when they appear to fill fissures, like veins, they have been deposited by some hydrothermal action under great pressure and at a high temperature. The constitution of these veins is the same as that of a very coarse granite. The feldspar is often in such coarse masses that it can be hand-picked. If crushed, the minerals may be separated by washing. The mica of commerce comes from similar deposits. The localities which have at one time or another been productive are very numerous, but the low price of the article, $5 per ton at Trenton, N. J., does not admit of expensive transportation. The other principal market is at East Liverpool, Ohio, both being centers of the American porcelain manufacture. In Maine quarries have been operated at Edgecombe, Lincoln County, and Brunswick, Cumberland County; in New York at Tarrytown, Westchester County, Fort Ann, Washington County, and Crown Point, Essex County. In Connecticut the quarries are very extensive, and are worked at South Glastonbury, Haddam, and Middletown. They furnish a large proportion of the total product. In Pennsylvania there is an extensive opening at Brandywine Summit, Delaware County, and in Delaware are several smaller ones in Newcastle County. Many other localities both in the East and the West are known, but the question of transportation is too serious to permit their profitable operation. The annual production of feldspar varies from 8000 to 15,000 long tons (2240 lbs.), worth about $5 per ton. It is used as a glaze for porcelain and as an ingredient in the body of the ware.

FLUORSPAR.

Almost the entire production of fluorspar in the United States comes from Rosiclare, Hardin County, Ill., although the mineral is known to occur in many other localities. Mr. S. F. Emmons described the Rosiclare mines in a paper read at the Baltimore meeting of the American Institute of Mining Engineers in February, 1892, of which the following is a brief abstract:

"There is, in the southern part of the State of Illinois, a series of deposits of fluorspar and galena, in which the former mineral occurs on a scale of magnitude unequaled, so far as I know, in any other part of the world. The mines were originally worked for lead alone, the fluorspar having little commercial value. Of late years these conditions have been reversed; an increasing market for fluorspar as a flux in smelting and for glass-making has been developed, and during the past decade the mines have been worked primarily for the spar, the lead product being of comparatively subordinate amount. As compared with the galena of other parts of the Mississippi Valley region, it is exceptional as containing from two or three up to nine ounces of silver per ton. Mining has been carried on in a desultory way in the counties of Livingston, Crittenden, and Caldwell, in Kentucky.

"The deposits of fluorspar and galena of Hardin County, Illinois, occur in the limestones which underlie the coal-measures of the States bordering on the Ohio River. The vein-fissures are evidently a system of fault-planes whose down-throw is on the hanging or west side, their strike varying from 5° to 40° east of north. An extent of mineral-bearing ground, nearly three miles in length, may be considered to be proved by the various openings that have been made, though an English miner named Wheeler, who has worked many years in the region, claims to have traced the vein 14 miles to the northeast.

"Even where the discrepancy of the adjoining walls is not seen, the veins bear undoubted evidence, in the banded or sheeted character of the vein-material, especially on the hanging-wall, of being strong fault-fissures. The stronger crevice is on the foot-wall side, where is found a solid mass of fluorspar from 2 ft. to 8 ft. wide, and sometimes as much as 12 ft. This spar is either colorless or has a slight yellowish tinge from infiltrated iron oxide. In immediate contact with the limestone foot-wall there is frequently found a varying amount of white, coarsely crystalline calc-spar, which grades off insensibly into fluorspar. The

delimitation of vein-material and country-rock on the foot-wall side is generally sharp and well defined, especially where there is some clay selvage. Where this is wanting, the limestone surface on the foot-wall side is apt to be irregular and wavy, evidently from unequal dissolving action of the mineral-bearing waters in the fissure. The hanging-wall side, which comprises generally half, or even more, of the material mined, is a mixed mass of spar and dragged-in rock-material, the proportion of the former decreasing so gradually from the solid spar outward that it is difficult to define the boundary of the deposit. It is in this portion that the banded arrangement of the material is most distinct, and it evidently consists of the more plastic portions of the country-rock, dragged into the fissure during the faulting movement, and more or less completely replaced by vein-minerals in proportion to the solubility of the materials. In those portions of the veins actually observed the unreplaced material was argillaceous, either shales or residues of impure limestones. The spar is here generally darker, deep purple colors prevailing. As no cross-cuts at all had been made in the workings visited, it was not possible to observe how far on either side of the vein the country-rock was fractured parallel to the vein, nor what was the character of the unaltered hanging-wall. It seems probable, however, that parallel crevices, in some cases carrying valuable mineral, may be found by cross-cutting.

"The occurrence of the galena is most irregular. It is generally in large, coarsely crystalline masses, entirely inclosed by and often intergrown with the fluorspar. In the extent observed it was not possible to determine any law with regard to its distribution. At one point it appeared to be concentrated on the foot-wall side of a 12-ft. mass of solid spar. At another, where the vein had pinched, it consisted of finely-banded fluorspar and galena, in which the two minerals were more often intergrown than with a defined plane of demarcation between them. Copper pyrites are found in very small grains, entirely inclosed in the galena, in unimportant amount. According to the testimony of the miners, the proportion of galena increases in depth, being very sensibly greater between 100 ft. and 200 ft. than above. In the lower workings of the Good Hope shaft continuous masses of galena of 100 tons weight are said to have been found. The occurrence of zincblende, which is of very subordinate amount in the upper workings, is apparently similar to that of galena. In the Cincinnati ground the vein-matter appears to have consisted mainly of calc-spar and zincblende, with but little fluorspar and galena.

"In the absence of accurate surveys it is difficult to speak with confidence as to the relation of the fissures developed by the different openings. The workings in the Mullins, Pell, Rosiclare, and Cincinnati grounds are evidently on one continuous fissure, and the Good Hope workings are very likely on the same fissure. The Blue diggings are on a parallel fissure *en échelon* with this, and I am inclined to consider the Daisy and Eureka workings as also on *échelon* fissures. The amount of mineral actually developed is very remarkable. In the Mullins, Pell, and Rosiclare workings observation and reliable testimony show a remarkably continuous deposit, which reaches 18 ft. to 20 ft., and rarely goes below 4 ft. in thickness; the average given for the whole vein is 10 ft. Nearly 3500 ft. in length are almost continuously opened, and explorations to depths of 200 ft. at various points have shown no diminution in the strength of the vein. It is

reasonable to assume that 1000 ft. additional in length are proved by the Good Hope workings. The Daisy workings, as far as opened, show a vein equal in strength and purity of fluorspar to the best of the older openings. The Eureka workings show an apparently regular and persistent vein of somewhat less width, being given at from 3 ft. to 8 ft., according to different authorities, but, as shown by the dumps, with a large proportion of pure fluorspar in its vein material.

"As regards the probable continuity of the deposits in depth, the predominance of evidence would seem to be in its favor. The mineral contents of the fissure, however, may be expected to vary with the character of the inclosing beds, and to diminish very much, if not to be cut off entirely, when the walls are formed by more siliceous and hence less readily soluble rocks."

PRODUCTION OF FLUORSPAR IN THE UNITED STATES SINCE 1880.

Year.	Amount, Tons of 2000 Lbs.	Value.	Year.	Amount, Tons of 2000 Lbs.	Value.
1880........	4,000	$16,000	1887........	5,000	$20,000
1881........	4,000	16,000	1888........	6,000	30,000
1882...	4,000	20,000	1889........	9,500	45,835
1883........	4,000	20,000	1890........	8,250	55,328
1884........	4,000	20,000	1891........	6,320	38,000
1885........	5,000	22,500	1892...	9,000	54,000
1886........	5,000	22,000			

Note.—The figures for 1880–90, both years inclusive, are from the *Mineral Resources of the United States*, 1889 and 1890; those for 1891 and 1892 are compiled from returns from producers.

There is a steadily growing demand for fluorspar, which is used as a flux in melting iron, in glass-making, in the reduction of aluminum, for the manufacture of hydrofluoric acid, and in the arts for making paints, enamels, mineral wool,

GOLD AND SILVER.

THE world's production of silver in 1891 amounted to 4,465,822 kilograms, of which the United States produced about 40.6%, Mexico 28.5%, Bolivia 8.4%, and Australasia 7%; thus these countries furnished 84.5% of the world's total supply. The aggregate yield of gold in 1891 was 188,531 kilograms, which, like silver, came chiefly from four countries. The United States supplied 26.4%, Australasia 25%, Russia 19.3%, and Africa 11.3%, or together no less than 82% of the whole. The product ratio between gold and silver in 1891 was 1:23.687; the value ratio was 1:20.92. Complete statistics of the world's production of gold and silver in 1892 are not yet attainable. It is certain, however, that there was an increase in the production of gold, while the production of silver will also, in all probability, show an increase, although less proportionately than in 1891.

The depreciation in the price of silver to a lower point than ever before recorded has been felt keenly in the United States, and some mines have been obliged to close down; but notwithstanding this fact the total output of the metal was larger than in any previous year. There was a falling off in the yield of silver from those ores which are reduced by amalgamation and lixiviation, and a general depression in the mining industry of Montana and Nevada, especially, in consequence thereof. On the other hand, there was an enormous increase in the production of silver from those ores which are treated by the lead-smelters, particularly in Colorado, where the year was one of unparalleled activity, and the output of silver several millions of ounces greater than in 1891. The increase in this State far more than compensated for the decrease in the others, and accounts for the unexpected rise in the aggregate production of the United States.

The production of gold in the United States was about the same in 1892 as in the previous year, California making its regular output, while Colorado and the Black Hills increased. For 1893, however, the prospect is for a notable increase in our production of gold. The discouraging outlook for silver is turning more capital and labor to gold-mining in Montana, Nevada, Arizona, and those States where the depression in silver has been felt most severely. It is also probable that hydraulic mining will be resumed in California to greater extent, as the restrictions which have prevented this branch of work for the past ten years are being

gradually removed, while the activity in South Dakota, which bids fair to be maintained, will lead to an increase in yield in that region.

From Australasia we have only partial statistics for the year 1892 at the present time, but they indicate an augmentation in the output of gold. Returns from the mines in Queensland for the first nine months of the year were 30,000 oz. in advance of the total for the same period in 1891; while the output of Bendigo, in Victoria, for the same number of months was so much greater than in the previous year that the total for that colony will undoubtedly show an increase. The silver product of Australasia has decreased somewhat on account of the less yield of the Broken Hill mines, which nevertheless was very large; these mines, however, are not likely to be able to maintain their enormous output much longer, owing to the lowering grade of the ores.

But little information leaks out concerning the gold mines of Russia, and there are absolutely no statistics of their yield later than 1891, when the output, though less than in 1890, was greater than in any other year since 1885; but our private information indicates an increased product in 1892.

The production of gold in Transvaal, South Africa, of which we have complete statistics, shows a remarkable increase—in itself more than enough to compensate for losses in all other countries. The gold-fields of British India also made a much larger output in 1892 than in the previous year. As for Mexico, our figures show a small increase in the production of gold and about the same production of silver as in 1891.

The recent monetary conference at Brussels has made it evident that unless some such plan as that proposed by the *Engineering and Mining Journal* for the general use of silver as money is adopted, the metal will necessarily before long take its place as a mere commodity, like iron, copper, nickel, and tin. All the principal nations of Europe have now established their monetary systems upon a gold basis, Austria-Hungary having completed arrangements for this step during the past year, and the United States remains the only country of importance engaged in the attempt to uphold silver as a noble metal. Economists recognize that continued purchases of silver by the United States Government would lead inevitably to the single silver basis, since with two kinds of money, of which one is inferior, the poorer invariably displaces the better, in accordance with Gresham's Law; and there is now an urgent demand that these purchases be stopped. When this is done, and it cannot long be deferred, the largest purchaser withdrawing from the market, the price of the metal will necessarily fall to an extremely low point—probably much below the average cost of production, on account of the accumulated stocks of the metal which will be thrown on the market. The world's production of silver in 1891 amounted to 143,550,000 troy ounces (4,465,822 kilograms), of which the United States produced 58,330,000 ounces and purchased 54,312,812 ounces.

It is impossible to arrive at any conclusive statistics of the cost of producing silver, owing to the fact that a large amount is the product of individual miners, small companies, and close corporations, whose cost sheets cannot be obtained; also owing to the closeness with which the silver-mining industry is interwoven with lead and copper mining. An immense amount of silver is produced from silver-lead and silver-copper ores which cannot be mined profitably for either metal

alone; still another important part of the whole is derived from silver-copper, silver-lead, and gold ores as a by-product purely. The more part of all the silver produced from silver ores proper is now reduced by the silver-lead smelters, the relative importance of the silver mills becoming less and less each year. The Director of the Mint, in his report on the production of gold and silver in the United States in 1891, estimated that 40% of the total production of silver that year came from lead ores, 10% from copper ores, and 50% from quartz and milling ores; of the last class, however, a considerable proportion is reduced by the lead-smelters in conjunction with the first class—silver-lead ores. Nevertheless, sufficient data can be obtained to enable us to form an opinion as to this subject.

In 1887 the Director of the Mint addressed letters to all the principal mines in the United States which might be classed as silver mines proper (producing no lead, copper, or gold in conjunction with silver, or if any, a trifling amount only), asking questions as to their output and cost of production. Tabulating the results thus secured, it appeared that 155 mines in the United States produced 17,655,387 oz. of silver at a cost of 52.4c. per oz. The total production of the United States in that year was 41,260,000 oz.; hence nearly 43% of the total was accounted for. Statistics collected by the *Engineering and Mining Journal* from official reports of mining companies and other reliable data for the year 1890 show that 17,757,025 oz. were produced from silver mines proper, at a cost of 50.6c. per oz.* The total production of silver in the United States in 1890 was 54,516,000 oz.; hence, about 32.5% of the total was accounted for. Following this article are given analyses of the reports of various mining companies, which indicate about the same results. The total production of silver in the United States in 1892 was, in round numbers, 60,000,000 oz., of which one half was produced probably at an average cost of 65c. per oz., and one half at 90c. per oz., or a general average of 77.5c.

Production of Gold and Silver in the United States.

Alaska.—A correspondent writes as follows: "The first practical step of any magnitude toward the opening up of the Yukon country was made during the past season by the establishment of a line of steamers on the river, with well-supplied trading-posts, by the North American Transportation and Trading Company, which is backed by abundant capital. The stock of provisions taken in last summer was the best and most complete ever seen in the Yukon. By way of the pass at the head of the river the company connects with its old stores at Chilcat and Chilcoot.

"The Sitka mining district, after several years of inactivity, has become lively again, and a large amount of development work has been done there. In the Juneau district the Juneau Mining and Milling Company has completed its electric plant, and next season intends to add ten more stamps to its mill.

"The Sheridan group of mines at Sheep Creek has been well developed during the past year, and has made a good showing. The Silver Queen mine has produced some very good silver ore. The Denver-Summit mine, Admiralty Island, is show-

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* This figure does not include interest on capital invested.

ing a good ore-body, and the vein is becoming better mineralized as the tunnel advances.

"The Alaska-Treadwell mine, Douglas Island, produced $871,361 in bullion in the 12 months ending Nov. 30, 1892. The ore from the lower level, 500 ft. deep, appears to be fully as good as that in the open cut. The Alaska-Mexican mine has been placed in London, and there is a possibility that a mill will be built this season."

Arizona.—Mr. John F. Blandy, M.E., of Prescott, contributes the following:

"Arizona's mining industry has, during 1892, suffered from the great depreciation of silver as has all the rest of the Rocky Mountain country. Many mines have closed down because they could not make a profit, and others because they have thought it best to leave the ore in the mines. However, one good result has grown out of this stoppage, more particularly with the 'chloriders;' namely, that they have turned very actively to looking for gold, and with very good results. Furthermore, work has been recommenced at many places upon old well-known ledges. The fear of the ores 'turning to base in depth' no longer troubles them, since the introduction of concentrators within the last few years into the Territory, more especially in Yavapai County, has taught the old miners something new. The richness of the pyrites of the Congress and Crown King mines and other places has done much to instruct the miners of the State as to the value of these ores.

"At no place have the results been greater than in the Galena district, some 20 miles southeast of Prescott, where three veins have been opened which have afforded base ores (iron pyrites) almost from the 'outcrop,' having a value from 2 oz. to 36 oz. gold per ton. These are not simply 'pockets' of rich ore, but regular veins with continuous ore. The greatest depth yet reached is 150 ft., and what change there has been is for the better. These veins vary in width from a few inches to four feet. Many claims have been located and at least a dozen of them can be classed as 'very good,' and of the dozen four or five as 'extra good.' A five-stamp mill has been doing duty for the district most of the year, treating the free gold outcrops, which have assayed from $20 to $65 per ton. If capitalists do not take hold of these mines, then the miners must wait until they can dig out enough to provide themselves with mills. This is being done at a fearful cost, as the transportation of the assorted ore to the sampler, together with freight and charges to the smelter, levies a tribute of $40 per ton—a very heavy charge against gold ore.

"To these may be added the Roach mine in the Turkey Creek district, now worked by arrastra, the ore averaging $50 per ton; the reopening of the Model mine in Peeples Valley; the discoveries in the Walnut Grove and Castle Creek districts; and the opening of the Gladiator in the Peck district. Silver-mining in Yavapai County may be said to have ceased, except at the 'Hillside,' now the 'Seven Stars,' where the ores carry about an equal amount of gold and silver. This property has lately changed hands.

"Mohave County is becoming quite noted in consequence of the great discoveries at the White Hills. Some 20 claims have been located there, and the period of prospecting having passed, regular mining and shipments of ores have commenced, the ores ranging as high as $1400 per ton. At first these were reported as pure silver ores, but those sent away have yielded from 2 oz. to 5 oz. per ton in gold.

The success of the White Hills district has rather stimulated the rest of the county, and vigorous work is being done upon several gold properties.

"In Yuma County there has been greater activity, but the Harqua Hala is the great and leading feature there. It has succeeded in making a production of $78,000 in one month with a 20-stamp mill. In Maricopa County the Vulture mine has attained new life, and has been running 10 stamps for some months. The Phœnix Mining Company has at last settled upon plans for improving its property, and is now erecting a mill, which will be in operation early in the coming year. The Union mine has been at work for some months very satisfactorily. These ores are auriferous pyrites, and are treated by the cyanide process.

"The mines of Pinal County, the Vekol, Jack Rabbit, Silver King, and Mammoth, have continued in operation throughout the year. To this list will shortly be added the Antelope gold mine, 40 miles north of Tucson, where it is expected that a Huntingdon mill will be running early this year, and as the ore is easily crushed and averages over $20 in free gold, good results may be expected.

"Pima County has suffered more from the depreciation of silver than any other section of Arizona, most of its mines being of that kind. Recent developments in the Oro Blanco and Arivaca districts give good promise of an increased yield in gold. The same may be said of silver-mining in Gila County. A gold mill is nearly completed in the Tonto Basin district by the Lackawanna Company, and it will soon be in operation. It claims to have very rich ore, free gold and pyrites. In Cochise County the usual activity has prevailed. The ores there being good for smelters, carrying a good percentage of lead with both gold and silver, and a comparatively low freight to Socorro and El Paso smelters, enables it to handle ores at a profit which could not be done in other sections of the Territory."

California.—There has been little change in the general condition of the mining industry in California during the past year. The bullion product of the precious metals varies little from year to year in this State, being usually about $13,000,000. Mr. Charles G. Yale furnishes the following information: "It is a noteworthy fact that the region in which gold-quartz mining first began in California—Nevada County—still leads the others in total product, number of mines, and general success, the deepest and best-paying gold mines of California being in that county. Water-power is used in driving the machinery of the principal mines, instead of steam, as formerly, and electric installations are now being made for transmitting the power that is thus generated all through the Grass Valley district. The same plan is being arranged in certain regions in Shasta County, where the ditches for this purpose are already built. Several mills in El Dorado County are also being run by power transmitted electrically, and the same system is to be applied in some of the drift mines on the Forest Hill divide in Placer County. It is expected that this will greatly cheapen the operations in the drift mines, where gravel has to be carried through tunnels several thousand feet long. Electricity has also been applied to the principal mines in the Bodie district, Mono County, power being there transmitted about 13 miles.

"Next to Nevada County, Amador is the largest gold producer in the State.

Calaveras and Placer counties still maintain a good product. It is the northern counties, however, that have shown the most marked improvements in the past few years. Many new mines have been opened in Shasta County, and more capital is being sent thither than ever before. In Trinity County both the quartz and hydraulic mines show more activity, while Siskiyou is rapidly increasing its product. In this region the hydraulic mines may be worked without interference, the Klamath River having been declared a non-navigable stream.

"It is highly probable that there will be before long a very decided change in the situation regarding hydraulic mining in California, which will result in a large increase in the gold product of the State. The fight over the débris question lasted for many years; in the end the miners were defeated, and the mines were closed down. Finally, however, the citizens of the State began to see that one of its greatest and most productive industries had been stopped; and when the miners organized and began to call for a reversion of the verdict, much sympathy and aid were extended to them by the press and the people generally. A resolution was adopted by the State Legislature asking Congress to investigate the matter, and Congress appointed a commission of engineers, who made an examination of the region, and reported that hydraulic mining might be resumed, without injury to the agricultural industries of the State, by the construction of a series of impounding dams to keep the débris out of the navigable streams. The miners held a convention, at which there were present delegates from the valley or anti-débris counties, and an agreement was arrived at between the two parties on the basis of the report of the Government engineers, a memorial being sent to Congress asking that body to adopt the plans suggested. As a result a bill was drawn up legalizing hydraulic mining when carried on under specified provisions, under the supervision of Government engineers, which has passed the House, and is now pending, with some slight amendments, in the Senate. In the mean time the United States Circuit Court has modified the injunction against the largest and most important hydraulic mine, and has permitted it to resume work, it having been shown that it had erected restraining works which would keep the débris out of the streams. Since this decision a number of other companies have commenced to build impounding dams on their own account, and it is probable, therefore, that operations will be resumed in more of the hydraulic mines in the course of the next year or two.

"As to silver, there is comparatively little produced in California, the amount now having fallen below $1,000,000 per annum. The principal region from which it comes is the Calico district, in San Bernardino County, though Inyo and Napa counties add a little to the total. The gold mines of the counties on the gold belt yield some silver, running in amount from $3000 to $15,000 per county, this silver being obtained with the gold in the milling operation."

The production of gold in California in 1892 is estimated at $12,775,000; of silver, $525,000, calculated at coining value, or about 400,000 oz.

Colorado.—The most noteworthy feature in precious metal mining in Colorado in 1892 was the remarkable activity in the silver-producing districts notwithstanding the great decline in the value of the metal. A larger output of gold was looked for, but no such increase in the yield of silver as the statistics show.

The production of Leadville in 1892 was smaller than in the previous year. The old mines of Fryer, Carbonate, and Iron hills are being exhausted gradually, and though new discoveries are made constantly in other parts of the district, their yield does not compensate for the decrease of the old mines. The center of activity in Leadville in 1892 was in the portion of the district between Harrison Avenue and Carbonate Hill, but although the ore chutes are known to extend into this ground they have not yet been opened extensively on account of the great flow of water encountered in all the shafts sunk there.

Aspen made a considerable increase in output in 1892, the famous Mollie Gibson mine having continued its shipments of extraordinarily rich ore, while new discoveries were made in the old Aspen mine. The consolidation of the Della S. and J. C. Johnson companies, putting an end to the litigation between them, was the means of bringing about a development on Smuggler Mountain far exceeding that of any previous year. At Creede progress has been steady, and the camp now ranks as the fourth largest producer of the State. Its output in 1892 is estimated at about 5,000,000 oz., and accounts largely for the great increase in the production of silver in Colorado during the year. The Last Chance and Amethyst mines have been the largest shippers.

The mines of Rico made a considerable increase in output in 1892, while the various districts of Ouray, San Juan, and San Miguel counties, in the San Juan Mountains, held their own. Cripple Creek, the new gold camp, it is estimated, produced between $1,200,000 and $1,500,000.

Several new smelting plants have been erected or planned during the past year. The Boston and Colorado Smelting Company increased its capital to $1,500,000 for the purpose of making additions to its works at Argo, while the Omaha and Grant Smelting and Refining Company is erecting 10 new blast-furnaces and 20 roasting and fusing furnaces, and making other improvements, which will cost over $1,000,000. New works have been erected and put in operation by the Hardinge Smelting Company, Aspen, capital $500,000; Holden Smelting and Refining Company, Aspen, capital $1,000,000; Bi-metallic Smelting Company, Leadville, capital $500,000; and Standard Smelting and Refining Company (silver-copper), Durango.

Idaho.—The chief event of the past year in Idaho was the strike in the Cœur d'Alene region during the summer, which necessitated a suspension of work in all the principal mines for a number of weeks, and resulted naturally in a decrease in the output of both lead and silver. The fight ended in a victory for the companies, the wages of shovelers being reduced from $3.50 to $3 per day, while those of miners remain at the former figure, which was the point aimed at. Impending labor troubles had been overshadowing the mining industry of the Cœur d'Alene for some time previous to the precipitation of the difficulties, and it is to be hoped that the troubles have now been brought to a conclusion, as, with the exhaustion of the carbonates of Leadville, Colo., this district of Idaho will become the most important source of the lead supply of the United States. A well-informed correspondent, writing of these mines, says :

"This Cœur d'Alene region is the most favorably situated for producing lead—the silver being almost a by-product—that I know of in the country. The mines

are not yet compelled to do much pumping and the ore is cheaply mined, while the numerous streams afford ample water-power. I think these mines can operate at a profit with the price of the white metal so low that most of the mines in the country are compelled to shut down."

The ores of the Cœur d'Alene are low-grade argentiferous galenas, occurring in veins of much width, some of which have already been opened to considerable depths with no indication of failure. The quantity of ore already exposed in this district must amount to millions of tons. The crude ore is dressed from five or six tons to one, the concentrates assaying 50% to 60% lead and 25 to 35 oz. per ton in silver. The output of the district since its discovery is given in the report of the Director of the Mint on the production of gold and silver in the United States in 1891 as follows:

Year.	Silver, Ounces.	Lead, Pounds.	Year.	Silver, Ounces.	Lead, Pounds.
1886	116,246	3,000,000	1889	1,095,265	35,000,000
1887	340,000	11,960,000	1890	1,499,663	55,000,000
1888	554,000	16,000,000	1891	1,825,765	66,000,000

As to the other silver mines of Idaho, the De Lamar, in Owyhee County, has been the largest producer. The mines at Silver City, in the same county, have also had a prosperous year, the old Poorman mine, which was such a large producer in 1865, having been worked with considerable success by its new English owners. The total production of the precious metals in Idaho, in 1892, is estimated as follows: Gold, 90,000 oz.; silver, 3,250,000 oz.

Montana.—The past year has not been a particularly prosperous one in the gold and silver mining industry of Montana, owing to the low price of silver, which has compelled many of the mines in districts where the ore is of low grade to close down. There has been, however, increased activity in gold-mining, and it is probable that the low price of the white metal, if continued, will lead to the reopening of more of the old gold mines, and will stimulate prospecting, particularly in the auriferous iron belts. In Butte, where the cost of production at the silver mines proper averages about 80c. per oz., the fall in silver has been felt severely, and these mines, with the exception of the Alice, are barely paying expenses ; but they eke out a little profit from custom-work. The Alice is said to be in bonanza in the neighborhood of the 1000-ft. level, prior to the discovery of which the company was not in a very prosperous condition.

The Granite Mountain mine, at Phillipsburg, is not believed to be making any money, and it is doubtful if it is paying current expenses. The Bi-metallic is in good ore and doing well, but the other silver properties in this district are not especially successful.

The Montana Company (Drumlummon mine), at Marysville, is barely paying current expenses. Early in the season it had a disastrous fire, destroying the pump lines and causing the flooding of the lower portion of the mine, which has resulted in a decreased output and an abnormally heavy expenditure. The Bald Butte mine, near the Drumlummon, completed its new 20-stamp mill in February, has had a prosperous year, and promises to become one of the most important gold-producers of the State.

The Jefferson County mines are producing silver-lead ore at a considerable profit. The old Wickes properties are now in the hands of Mr. O. R. Allen as manager, who has succeeded in wringing a considerable profit from them. These properties were formerly a part of the Helena and Livingston Smelting Company, which was the successor of the old Montana Company (not the one at Marysville), which in turn was the successor of some other failure. The old mine is developed to great depth, and equipped with suitable machinery. This is another evidence that good management will revive many an old-time unprofitable mine in Montana.

The Castle and Barker districts (both silver-lead), in Meagher County, have suffered from the general depression. The Cumberland, which is the only producer of consequence at Castle, shut down early in the year, and since that time there have been no shipments of ore or bullion from that camp. Castle is 70 miles from Livingston, the nearest railway point, and the cost of transportation is evidently the reason for the suspension of operations. In June the floods damaged seriously the branch railroad to Barker, and for three months there were no shipments of ore; since that time the output has been small.

The Placer Creek region, where the veins are only from four to six inches in thickness, is producing its usual quantity of high-grade ore, and is paying handsomely. The ore is an iron sulphide, carrying lead in bunches, the average value for years past being about $44 per ton in silver and gold. Following this range (which is known as the Crow Creek range) to the east is the famous Elkhorn mine, and farther to the south are the auriferous iron properties of Radersburg, which are not prosperous. This may be said of most of these iron properties—due, probably, to the fact that the Montana miners do not take kindly to the chlorination process. They are experimenting with the cyanide process; but there are no reports, as yet, of any very definitely successful installations.

The old Cardwell district, in the neighborhood of Whitehall, has been revived by a newly organized concern, the American Developing and Mining Company, which is likely to develop a very productive auriferous iron property, with ore beautifully adapted to chlorination. This process will doubtless be adopted, and it may be the pioneer of many profitable plants of this description in Montana. The grade of this ore will range from $12 to $16; and considering that the railroad runs parallel with the range within from two to eight miles, this region appears to be one of the most promising in the State.

The Elkhorn mine is still paying its high rate of dividends. It is a wonderful mine; but it is generally believed that the richer ores are being extracted in undue proportion, and about as fast as they are developed. If this is so, it is but a repetition of the history of English mining in America.

The Helena and Victor property, in Missoula County, has been reasonably productive in the past. It is a silver-lead mine, with ore comparatively low in grade, but producing a very satisfactory concentrate. The mine was allowed to cave, and the new management has been obliged to abandon the production of ore while the workings are being reopened.

In the Boulder region, about 60 miles south of Livingstone and immediately north of the National Park, there has been developed during the past year one of the most promising gold belts in the State. The veins are narrow, but of good

grade, and the ore yields readily to plate amalgamation. This ore will also become a sulphide in depth.

Our Montana correspondents estimate the production of gold in the State in 1892 at 150,000 fine ounces, and of silver as 14,500,000 fine ounces.

Nevada.—During the year 1892 mining in Nevada suffered a still further decline. As the ores outside of the Comstock are almost wholly silver, the State would naturally be at a great disadvantage at the present price of the metal, but it is affected to a greater extent by the lack of transportation facilities.

Affairs in Eureka were extremely dull, the only large producer being the Diamond, which shipped a considerable quantity of ore to Salt Lake. The Eureka Consolidated and the Richmond Consolidated produced small quantities of bullion and ore, but solely from the work of tributers. The Ruby and Dunderberg mines closed down absolutely, as did many of the smaller ones. The Cortez Mines, Limited, which had been among the largest producers and dividend payers in Nevada, were shut down for almost the entire year, owing to the low price of silver, but it is now understood that they will start up again.

In White Pine some activity was caused by an apparently unfounded rumor that the Eberhardt tunnel had struck a valuable ore body on Treasure Hill. It was rumored also during the year that the Pioche Consolidated Mining and Smelting Company's mines and plants at Pioche had been sold to the Consolidated Kansas City Smelting and Refining Company for a large sum. An examination was made of the property, but on the decision of the engineers it was not purchased, and was then shut down by the owners. Attempts were made in the latter part of the year to rework the tailings in the Raymond & Ely and Meadow Valley at Bullionville, but without marked success.

ANNUAL YIELD OF GOLD AND SILVER OF THE COMSTOCK LODE SINCE ITS DISCOVERY.

Gold valued at $20.67 per oz.; silver at $1.2929.

Year.	Gold.	Silver.	Total.	Year.	Gold.	Silver.	Total.
1859(*a*).	$30,000 00	....	$30,000 00	1879(*e*)...........	$2,801,394 33	$4,202,091 49	$7,003.485 82
1860(*a*).	525,000 00	$225,000 00	750,000 00	1880(*f*)...........	2,051,606 00	3,077.409 00	5,129,015 00
1861(*a*).	2,450,000 00	1,050,000 00	3,500,000 00	1881(*f*)...........	430,248 00	645,372 00	1,075,620 00
1862(*a*).	4,690,000 00	2,010,000 00	6,700,000 00	1882(*f*)...........	697,385 60	1,046,078 40	1,743,464 00
1863(*b*)..	4,960,000 00	7'440,000 00	12,400,000 00	1883(*f*)...........	802,539 54	1,203,809 29	2,006,348 83
1864(*b*)..	6,400,000 00	9,600,000 00	16,000,000 00	1884(*f*)...........	1,261,313 60	1,577,438 40	2,838,752 00
1865(*c*)..	5,133,487 94	7,700,231 89	12,833,719 83	1885(*f*)...........	1,729,531 25	1,415,071 04	3,144,602 29
1866(*c*)..	5,963,157 67	8,944,736 51	14,907,894 18	1886(*f*)...........	2,054,920 15	1,681,298 31	3,736,218 46
1867(*b*)..	5,495,443 20	8,243,164 80	13,738,608 00	1887(*f*)...........	2,481,176 85	2,030,053 78	4,511,230 63
1868(*b*)..	3,391,907 60	5,087,861 40	8,479,769 00	1888(*f*)...........	3,169,209 07	4,458,058 66	7,627,267 73
1869(*b*)..	2,962,231 20	4,443,346 80	7,405,578 00	1889(*f*)...........	2,590,973 32	3,358,949 95	5,949,923 27
1870(*d*).	3,481,730 16	5,222,595 24	8,704,325 40	1890(*g*)...........	2,002,000 00	3,087,000 00	5,089,000 00
1871(*e*)..	4,099,811 46	6,149,717 19	10,249,528 65	1891(*g*)...........	1,200,000 00	1,900,000 00	3,100,000 00
1872(*e*)..	4,894.559 86	7,341,839 79	12,236,399 65				
1873(*e*)..	8,668.793 40	13.003.187 13	21,671,980 53	Total	140,771,979 28	197,674,649 69	338,446,628 97
1874(*e*)..	8,990.714 06	13,486,071 09	22,476,785 15	Bullion from tailings 1871-89	....	....	12,709,039 71
1875(*e*)..	10,330,208 62	15,495,312 92	25,825,521 54				
1876(*e*)..	12,647,464 08	18.971,196 12	31,618,660 20				
1877(*e*)..	14,520.614 68	21,780,922 02	36,301,536 70	Grand total..	....	....	351,155,668 68
1878(*e*)..	7,864,557 64	11,796,836 47	19,661,394 11				

(*a*) From J. C. Corey, Almarin B. Paul, and Dr. E. B. Harris, three of the first quartz-mill men in Gold Cañon in 1859-60, reducing Comstock ore.
(*b*) From J. D. Hague's *Report on Mining Industry of the Fortieth Parallel*, 1870, competently corroborated.
(*c*) From the records of Wells, Fargo & Co.'s Express.
(*d*) From official mining data and best information.
(*e*) From 1871 the figures are from sworn quarterly statements of mining companies to the assessor for bullion taxation; but owing to the notorious swindling in the management of the mines by the "mill ring," these figures probably are much below the actual output.
(*f*) From the official records of mining companies.
(*g*) Estimated by S. C. Wright, Superintendent United States Mint, Carson City, Nev.

A new district which yielded very rich surface ore was opened south of Pioche. One of the mines here which produced a considerable quantity of very rich gold and silver ore was bonded by Salt Lake parties, who expended considerable money in development work, but they relinquished their bond at the end of the year. In Nye County, at Tybo and Reveille, nothing of any importance was done.

At the end of the year the greater portion of the Tuscarora mines was closed down, only eight men remaining at work in the Navajo. The Defries and Coptis ran continuously and are considered two promising small mines. During the year a disclosure was made that one of the superintendents for the "ring" which controls the Tuscarora mines had purloined a considerable amount of bullion; $30,000 of this was recovered in Carlin, but the superintendent was not discharged, as he is supposed to have fortified himself by a thorough acquaintance with the dangerous secrets of the inside. It is thought that this robbery of the stockholders had been going on for years.

Little was done in Humboldt, Churchill, or Lander counties. In Esmeralda County the Mount Diablo started running at the end of the year. The Indian Queen and Poorman litigation was settled, and these mines have begun to produce largely. There is some talk of resuming operations at Silver Peak, but nothing as yet has been done.

New Mexico.—The mining industry of New Mexico, on the whole, was in less favorable condition at the end of 1892 than it was at the end of 1891. The low price of silver has closed some of the mines while others have been exhausted, and few new ore bodies of any extent have been discovered. In the gold-mining districts Pinos Altos maintained the lead, although its production was diminished as compared with 1891. The Manhattan Gold-mining Company, which owns one of the principal mines, devoted itself to development work, while the Mountain Key, formerly a good producer, remained idle a great part of the year. The Old Abe, a very promising gold mine near White Oaks, was developed during the year, and this property and some neighboring ones will probably prove productive in 1893.

A large production of lead and silver ores was made at Cook's Peak, but the low price of both metals toward the close of the year lessened activity in this very promising district. Its ores are carbonates, of low grade in silver but rich in lead, and are found in large bodies, near the surface. A decision was rendered in the Cañon del Agua suit during the year, canceling the title to that property and throwing it open to location; the principal companies, however, such as the San Pedro and the Lincoln-Lucky, had previously relocated their claims.

Oregon.—Mr. William Huntley Hampton, E. M., sends the following notes: "The mining industry in Oregon during 1892 showed decided improvement. The principal gold mines of the State are situated in the southwestern section, where there is a large number of small but rich veins, at which, in some instances, small mills have been erected and worked. Baker and Union counties have made the most progress in 1892, additions having been made to many of the existing plants, and several sales of mining property having been effected. So far, however, the ore of the Eureka-Excelsior mines has not been treated successfully, and the mill is now shut down; numerous experiments were made during the past year, and there is considerable faith expressed in the eventual success of the efforts. Silver-mining

in Oregon is confined to Baker and Grant counties, but the Monumental mine in the former is the only one in the State that is equipped with a stamp-mill. The works of the Portland Smelting and Refining Company were operated at periods during the year, and treated considerable ore from Oregon, California, Nevada, Washington, Idaho, and Montana."

South Dakota.—The past year has been a very prosperous one in South Dakota, attention having been driven, by the low price of silver, to the low-grade gold mines of the State, as well as to those containing ore of higher grade but rebellious in character. On the Homestake belt the Big Missouri, the Hawkeye, and the Minnesota mines were started, all of which have more or less promise of success; but by far the greatest activity has been devoted to the rebellious ore deposits near Bald Mountain and Ruby Basin, where the Golden Reward Mining Company, the Welcome Milling and Smelting Company, the Deadwood and Delaware Smelting Company, and other corporations and individuals have purchased large numbers of claims and intend to work these ores, which occur in wide, flat bodies, by the improved barrel chlorination process, or by the pyritic smelting process used at the Deadwood and Delaware smelter. The outlook for the Black Hills for the next few years is as favorable as in any Western mining district.

Southern States.—Mr. Stuart W. Cramer, M.E., contributes the following valuable article on the gold and silver mining industry of these States:

"The first authentic find of gold in the United States was that of the Reed nugget in North Carolina, 1799. It was followed by discoveries in the other Appalachian States, so that by 1830 the annual production exceeded $500,000. Tradition, however, indicates that systematic mining was carried on many years previously, notably at the Brewer mine, Chesterfield County, South Carolina. In fact neither history nor tradition accounts for the "Aborigines Shaft" at this mine.

"Work was at first confined to placer deposits and to the easily worked outcrops of veins. The yearly output reached its maximum of nearly $2,000,000 between 1843 and 1848, when the California excitement created an exodus among the miners that steadily decreased the production until the breaking out of the war put an end to all operations. It was well on toward 1870 before systematic work was resumed. By this time the easily available deposits being well-nigh exhausted, attention was naturally drawn to the refractory ores existing below water-level. The first successful attempt at treating them was made in 1881 by A. Thies, at the Phœnix mine in North Carolina, with the barrel chlorination process; this has gradually developed into the thoroughly modern plants at the Haile and Brewer mines. The cyanide process recently introduced at the Franklin mine in Georgia may also be said to be successfully established in the district, while a market has been opened for both gold and silver bearing sulphides, even when considerable lead and zinc are present, by the North Carolina Smelting Company at Thomasville, N. C.

"As to the total production of the South up to the present time, the records are very incomplete, and estimates are necessarily matters of opinion. Being in charge of the United States Assay Office at Charlotte, N. C., I have had every facility for investigating the subject, and submit the following table with the conviction that

it represents very nearly the actual production. However, some explanation as to how these estimates were made is necessary to make them of value as statistics.

"Prior to 1848, $12,808,575 of domestic production was deposited at the mints of the United States, of which all except $37,850 was recorded as being from the Southern States. For the total production of this period I have adopted Dr. Raymond's estimate of $24,936,769 (see Raymond's reports). It will be seen that here the recorded production is 51½% of the gross production. At this time, however, California gold began to displace Southern gold for jewelry and like purposes; so there is little doubt that from 1848 to 1879 at least 65% of the production found its way, properly recorded, into the mints. Since 1879 reliable estimates of the annual production have appeared in the Mint reports, of which those from 1889 to 1892, inclusive, were prepared by myself.

ESTIMATED PRODUCTION OF GOLD AND SILVER IN THE SOUTHERN STATES.*

Year.	Maryland.	Virginia.	North Carolina	South Carolina	Georgia.	Alabama.	Tennessee.	Total.
1799-1879	$2,500	$3,091,700	$19,659,600	$2,587.900	$14,180,500	$365,300	$155,300	$40,042,800
1880	250	11,500	95,000	15,000	120,000	1,000	1,500	244,250
1881	500	10,000	115,000	40,000	125,000	1,000	1,750	293,250
1882	1,000	15,000	215,000	25,000	250,000	3,500	250	509,750
1883	500	7,000	170,000	57,000	200,000	6,000	750	441,250
1884	500	2,500	160,500	57,500	137,000	5,000	300	363,300
1885	2,000	3,500	155,000	43,000	136,000	6,000	300	345,800
1886	1,000	4,000	178,000	38,006	153,500	4,000	500	379.000
1887	500	14,600	230,000	50,500	110,500	2,500	500	409,100
1888	3,500	7,500	139,500	39,200	104,500	5,600	1,100	300,900
1889	3,500	4,113	150,174	47,085	108,069	2,639	750	316,330
1890	16,962	6,496	126,397	100,294	101,318	2,170	1,001	354,638
1891	11,264	6,699	101,477	130,149	80,622	2,245	519	332,975
1892	1,000	5,002	90,196	123,881	95.251	2,419	1,006	318,755
Total	$44,976	$3,189,610	$21,585,844	$3,354,509	$15,902,260	$409,373	$165,526	$44,652,098

* Does not include the States west of the Mississippi River.

PRODUCTION OF GOLD AND SILVER IN THE SOUTHERN STATES IN 1892.

States.	Gold.		Silver.		Total Value.
	Fine Ounces.	Value.	Fine Ounces.	Coining Value.	
Maryland	48.125	$994.83	4.00	$5.17	$1,000.00
Virginia	240.417	4,969.87	25 00	32 32	5,002.19
North Carolina	3,800 335	78,559.90	9,000.00	11,636.36	90,1 6.26
South Carolina	5,967.761	123,364.56	400.00	517.17	123,881.73
Georgia	4,582.751	94,733.85	400.00	517.17	95,251.02
Alabama	115.773	2,393.24	20.00	25.85	2,419 09
Tennessee	48.361	999.71	5.00	6.46	1,006.17
Total	14,803.523	306,015.96	9,854.00	12,740.50	318,756.46

"The production of gold and silver in the Southern States during the past year indicates but little change in the condition of the industry. There has been, however, a gradual tendency toward more systematic work and improvements in methods. In Maryland and Virginia organized mining is at a standstill, the only work of any description in Maryland being that during the early part of the year at the Alton mine, near Great Falls, Montgomery County. In Virginia the Whitehall and other mines were exploited to a limited extent, but nothing was added to the production by these operations. Prospecting and petty work were carried on in several counties. In North Carolina there was a decided falling off in the

production, although toward the close of the year the outlook was better. The Marion Bullion Company, at Deming, erected a concentration plant and mill, it is said, and chlorination works. The Silver Valley mine, in Davidson County, was in active operation, shipping argentiferous zinc-lead ores to the smelter at Thomasville. Montgomery County has been the largest producer in this State for years, but there has been a steady decline of late. In South Carolina the situation is encouraging. The production is almost entirely the output of the Haile and Brewer mines. A limited amount of work has been done in other counties, but there is little petty mining in this State. In Georgia the operations of the past year were somewhat greater than in the previous. The outlook for 1893 is good. The Hand Company, at Dahlonega, did considerable experimental work, which somewhat curtailed the regular output. Its ore carries more sulphurets than formerly, and a change in the treatment is desirable. Of the 140 stamps in the several mills of the company, only about 100 dropped regularly during the year. The Creighton Mining and Milling Company has taken hold of the Franklin mine, Cherokee County, and erected cyanide works which materially added to the production during the last three months. Very little work was done during the year in either Alabama or Tennessee."

Texas.—This State continues to be a small producer of gold and silver, the first recorded product having been made in 1886, since which time the output has been slowly increasing. Mr. E. T. Dumble, State Geologist, contributes the following notes:

"Gold and silver ores, occurring in connection with those of copper, lead, and zinc, are found both in the central mineral district of Texas (Llano, Mason, and adjoining counties) and in Trans-Pecos. In the central district there has been some prospecting during the past year and numerous finds are reported, but no great amount of work has been done on these deposits. In the Trans-Pecos district the mines, which have been operated for several years, have been worked steadily, and are yielding as well as ever. These are the Shafter and Cibolo mines, near Shafter, Presidio County, and the Hazel mine, in the Diablo Mountains.

"In the Presidio mine, discovered in 1880, the ore (free-milling) is found in pockets of irregular shape, generally isolated from each other, in a limestone country-rock. The Cibolo has ore-bodies of the same character, but in addition has one in a well-defined fissure. These mines are both operated by one company, which runs a 10-stamp mill and ships from 30,000 to 40,000 oz. of silver monthly.

"The Hazel mine is about 10 miles north of Alamore Station, on the Texas Pacific Railroad. The vein, which is nearly perpendicular, has a width of nearly 34 ft. at the top, but below the 500-ft. level widens to over 40 ft. The walls are a fine-grained red sandstone. The ore, some of which is rich, is shipped for treatment.

"Besides these mines, there are several others in the district, among which may be mentioned the Bonanza and Alice Ray, in the Quitman Mountains, which are promising but undeveloped prospects. Small shipments may have been made from some of these, but the amount cannot be much."

Utah.—Mr. A. Hanauer, Jr., furnishes the following article on Utah's gold and silver mining industry in 1892:

"Five counties in Utah have contributed the bulk of the Territory's production of the precious metals, viz., Summit, Juab, Salt Lake, Tooele, and Beaver. Prospecting was begun in the early 'sixties,' but not until the completion of the Union Pacific Railway did the output assume sufficient proportions to engage the attention of local or outside statisticians.

"In Summit County, the famous Ontario and Daly mines at Park City, with their reduction works, which treat from two thirds to three fourths of their tonnage, the remainder being sold to smelting works, are the most important mines of the Territory. Besides these there are such important silver-lead producers as the Anchor, Crescent, Woodside, Mayflower, and Silver King. This county shows the one notable increase for the past year over 1891. The output in that year was 88,380 tons of ore, containing 3,450 oz. gold and 3,865,570 oz. silver. Careful estimates for 1892 make the tonnage 100,000, with an increase of fully 10% in silver and gold.

"For years past this district has averaged over half of the silver product of the Territory, and its increase in production has kept pace with the general increase of the Territory at large, as shown by the following table, the figures being taken from the annual reports of the Director of the Mint upon the production of gold and silver in the United States:

Year.	Tonnage, Park City.	Silver, Park City. Ounces.	Total Silver, Utah. Ounces.	Year.	Tonnage, Park City.	Silver, Park City. Ounces.	Total Silver, Utah. Ounces.
1885	——	3,126,890	5,981,750	1889	77,255	3,800,266	7,106,886
1886	——	2,881,436	5,539,940	1890	76,660	3,120,063	8,229,405
1887	——	3,157,453	6,050,550	1891	88,380	3,865,570	8,750,352
1888	63,255	3,398,126	5,848,088	1892*	100,000	4,200,000	8,804,785

* Estimated.

"Salt Lake County has two producing regions, divided by the Salt Lake or Jordan Valley. In the East, in the Wasatch Mountains, are Big and Little Cottonwood, regarded as a continuation of the mineral zone of which the Park City district is a part. While the tonnage of these districts is not great and is confined to a limited number of mines, the districts contain such famous producers as the Emma, Flagstaff, Maxfield, and Vallejo. The tonnage averages about 2000 per annum. To the west, in the Oquirrh Range, lies Bingham, which has furnished the bulk of the lead output of the Territory. Gold placers have also been worked there continuously since the original discoveries, but the importance of Bingham lies mainly in its lead output. Its ore output for the past ten years has averaged about 40,000 tons per annum, reaching 53,000 tons in 1891. During the past year there has been a falling off of about 8,000 tons, due to the low price of silver and lead.

"Salt Lake County is also the seat of Utah's smelting industry, and has three smelting works in operation, the Germania, the Mingo, and the Hanauer, with an aggregate of 15 furnaces and a united capacity of over 500 tons of ore per day. Their combined output for 1892 was 21,000 tons of silver-lead bullion.

"Juab County is essentially a silver and gold producer. Its silver output is the second largest in the Territory, and as a gold producer it easily ranks first. Its principal mines are the Eureka Hill, Bullion-Beck and Champion, Mammoth, Centennial-Eureka, Caroline, and Gemini. These mines are in the old and well-

developed districts of Eureka, Silver City, and Tintic. Some of them have been idle for a considerable portion of the year, lowering the aggregate tonnage output of the county fully 25%.

"During the past two years a great deal of attention has been attracted by the stretch of country known as the 'Deep Creek' region, and much prospect work has been done in it. It extends across the border into Nevada, the Utah portion being the western sections of Juab and Tooele counties. Fish Springs, in Juab County, has so far shown the most activity and best results. In 1891 this district shipped 835 tons of ore to the Salt Lake City market, containing 60 oz. gold and 108,300 oz. silver. A low estimate doubles this output for 1892, which will in a measure counteract the decrease in the older districts of the county.

"Beaver County has the Horn Silver mine, its only producer of any magnitude, which, after paying some $4,000,000 in dividends, suffered a partial eclipse for a few years, but is again entering the list of large producers, and has averaged over 20,000 tons per annum for the past three years. In 1889 the output was 11,614 tons; in 1890, 18,957 tons; in 1891, 24,175 tons; and in 1892 about 22,000 tons. Small shippers add from 1,000 to 2,000 tons annually to the product of the county.

"Neither Tooele, Washington, nor Utah County has any great producer; and Emery, Box Elder, Wasatch, Piute, and Millard counties, while occasionally marketing small lots, have not as yet materially affected the total of any year. Tooele's main shipper during the past two years has been the Ophir Hill Mining Company. Part of the Deep Creek region lies in this county, but only one district (Dugway) has so far become worthy of mention, whence the Buckhorn mine, in 1891, shipped 140 tons of ore, containing 200 oz. gold and 20,000 oz. silver. In Washington County there has been a steady decline for the past ten years. The mines occur there in a sandstone ridge, and Silver Reef has been known to produce as much as 40,000 to 50,000 tons of ore annually, averaging over 20 oz. per ton. Four stamp-mills, belonging to as many companies, were kept at work reducing these ores, but of late the output is much smaller than it was in the early years of the 'Reef's' history

"Notwithstanding the low price of silver and lead during 1892, it appears at the present writing, from the most reliable data, that the tonnage output, as well as the production of silver and gold, will not vary materially from the preceding year. The gain in Summit County and in the Deep Creek region will go far to neutralize losses elsewhere. The outlook for 1893, however, unless there is a marked improvement in the price of either or both of these metals, is most discouraging. As 1892 draws to a close, rumors of compulsory shut-downs reach one from all sides, and the passing of the Ontario dividend, with assessments on the stock of the Anchor and Crescent companies, are by no means reassuring.

"Mr. J. E. Dooly, cashier of Wells, Fargo & Co., estimates the production for the year as follows, comparison being made with the estimate from the same source for 1891:

Year.	Lead, Pounds.	Silver, Ounces.	Gold, Ounces.
1891	86,526,528	8,915,223	36,160
1892	91,117,107	8,969,656	38,182
Gain	4,590,579	54,433	2,022

"The report of the Director of the Mint for 1891, compiled after the close of the year, gives Utah's production as 8,750,352 oz. silver and 31,644 oz. gold. Allowing the same discrepancy for 1892 (easily explained when the difficulty of obtaining absolute accuracy in reports made up before the close of the year is considered), and taking Mr. Dooly's figures on lead, we have as the production of Utah for 1892: 91,117,107 lbs. lead, 8,804,785 oz. silver, and 33,666 oz. gold.

"Mr. Dooly's detailed annual reports begin with 1877. Prior to that date reliable statistics in detail are not obtainable. I am, however, indebted to Mr. J. J. Valentine, President of Wells, Fargo & Co., for the aggregate output for the years 1871 to 1876, inclusive (each year's output figured in dollars, and not in pounds or ounces), from which I am able to estimate the total production of Utah Territory, including 1892, as follows: 553,000 tons lead, 110,000,000 oz. silver, and 300,000 oz. gold."

General Statistics of Gold and Silver in the United States.

The earliest attempt to distribute the bullion product of the United States among the several States and Territories was for the year 1866, but until 1877 no division was made between gold and silver except in the aggregate, and only the aggregate was estimated for 1876. Some of these totals have been greatly reduced in subsequent reports of the Director of the Mint, as is shown in the latest Mint estimates given at the foot of the following table:

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES.

(The estimates for 1792–1873 are by Dr. R. W. Raymond, United States Mining Commissioner; since 1873, by the Director of the Mint.)

Years.	Gold.		Silver.		Years.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.		Ounces.	Value.	Ounces.	Value.
1792–1834.	677,310	$14,000,000	....	$(a)	1869......	2,394,775	$49,500,000	9,281,520	$12,000,000
1834–44...	362,844	7,500,000	193,365	250,000	1870......	2,418,965	50,000,000	12,375,360	16,000,000
1845......	48,782	1,008,327	38,673	50,000	1871......	2,104,899	43,500,000	17,789,465	23,000,000
1846......	55,121	1,139,357	38,673	50,000	1872......	1,741,654	36,000,000	22,254,002	28,750,000
1847	43,013	889,085	38,673	50,000	1873......	1,741,654	36,000,000	27,665,712	35,750,000
1848	483,793	10,000,000	38,673	50,000	1874......	1,620,706	33,500,000	28,865,418	37,300,000
1849......	1,935,172	40,000,000	38,673	50,000	1875......	1,615,868	33,400,000	24,533,993	31,700,000
1850	2,418,965	50,000,000	38,673	50,000	1876......	1,930,333	39,900,000	30,010,054	38,800,000
1851......	2,660,861	55,000,000	38,673	50,000	1877......	2,268,988	46,900,000	30,783,509	39,800,000
1852......	2,902,758	60,000,000	38,673	50,000	1878......	2,476,800	51,200,000	34,960,000	45,200,000
1853	3,144,654	65,000,000	38,673	50,000	1879......	1,881,787	38,900,000	31,550,000	40,800,000
1854......	2,902,758	60,000,000	38,673	50,000	1880......	1,741,500	36,000,000	30,320,000	39,200,000
1855......	2,660,861	55,000,000	38,673	50,000	1881......	1,678,612	34,700,000	33,260,000	43,000,000
1856......	2,660,861	55,000,000	38,673	50,000	1882......	1,572,187	32,500,000	36,200,000	46,800,000
1857......	2,660,861	55,000,000	38,673	50,000	1883......	1,451,250	30,000,000	35,730,000	46,200,000
1858......	2,418,965	50,000,000	386,730	500,000	1884......	1,489,950	30,800,000	37,800,000	48,800,000
1859.	2,418,965	50,000,000	77,356	100,000	1885......	1,538,325	31,800,000	39,910,000	51,600,000
1860......	2,225,447	46,000,000	116,019	150,000	1886......	1,693,125	35,000,000	39,685,513	51,000,000
1861	2,080,309	43,000,000	1,546,920	2,000,000	1887......	1 596,375	33,000,000	41,721,592	53,350,000
1862......	1,896,468	39,200,000	3,480,547	4,500,000	1888.. ...	1,604,841	33,175,000	45,792,682	59,195,000
1863......	1,935,172	40,000,000	6,574,867	8,500,000	1889(*b*)....	1,590,868	32,886,744	51,354,839	66,396,988
1864......	2,225,447	46,100,000	8,508,060	11,000,000	1890......	1,588,880	32,845,000	54,516,300	70,465,000
1865......	2,574,897	53,225,000	8,701,369	11,250,000	1891... ..	1,604,840	33,175,000	58,330,000	75,416,000
1866......	2,588,292	53,500,000	7,734,600	10,000,000	1892......	1,596,516	33,000,000	64,900,000	83,909,210
1867......	2,502,419	51,725,000	10,441,643	13,500,000					
1868......	2,322,206	48,000,000	9,281,520	12,000,000	Total.	95,292,251	1,969,692,949	896304,346	1,158,831,896

(*a*) Insignificant. (*b*) The figures for 1889 are those compiled for the Eleventh Census. The estimate of the Director of the Mint for the same year is: Gold, $32,800,000; silver, $64,646,000—total, $97,446,000.

Note.—The silver is calculated at the United States coining value = $1.2929 per ounce.

Referring to the preceding table, Mr. R. P. Rothwell, special agent of the Eleventh Census, says, in his report on gold and silver:

"The above figures, especially for the years prior to 1879, vary considerably in many cases from those published in earlier reports, the latter being made up from estimates made at the time, and based upon returns which were often greatly exaggerated. Thus in the above table the total bullion production of 1866 is given as $63,500,000, while the original report published in 1867 gave it at $106,000,000."

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES, BY STATES, SINCE 1866.

States and Territories.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.
Arizona	....	$500,000	$500,000	$1,000,000	$800,000	$800,000	$625,000	$500,000	$487,000	$750,000	....
California	$25,000,000	25,000,000	22,000,000	22,500,000	25,000,000	20,000,000	19,049,098	18,025,722	20,300,531	17,753,151	....
Colorado	17,000,000	2,500,000	3,250,000	4,000,000	3,675,000	4,663,000	4,661,465	4,020,263	5,188,510	5,302,810	....
Idaho	17,000,000	6,500,000	7,000,000	7,000,000	6,000,000	5,000,000	2,695,870	2,500,000	1,880,004	1,750,000	....
Montana	18,000,000	12,000,000	15,000,000	9,000,000	9,100,000	8,050,000	6,068,339	5,178,047	3,844,722	3,573,600	....
Nevada	16,000,000	20,000,000	14,000,000	14,000,000	16,000,000	22,500,000	25,548,801	35,254,507	35,452,233	40,478,369	....
New Mexico	....	500,000	250,000	500,000	500,000	500,000	500,000	500,000	500,000	325,000	....
Oregon and Washington	8,000,000	3,000,000	4,000,000	3,000,000	3,000,000	2,500,000	2,000,000	1,585,784	763,605	1,246,978	....
Utah	....	....	....	....	1,300,000	2,300,000	2,445,284	3,778,200	3,911,601	3,137,688	....
Wyoming	....	....	....	....	100,000	100,000	100,000	50,000	....	....	....
Other sources	5,000,000	5,000,000	1,000,000	500,000	525,000	250,000	250,000	250,000	100,000	500,000	....
Total	$106,000,000	$75,000,000	$67,000,000	$61,500,000	$66,000,000	$66,663,000	$63,943,857	$71,642,523	$72,428,206	$74,817,596	$85,250,000
Latest Mint estimate	63,500,000	65,225,000	60,000,000	61,500,000	66,000,000	66,500,000	64,750,000	71,550,000	70,800,000	65,100,000	78,700,000
Gold	53,500,000	51,725,000	48,000,000	49,500,000	50,000,000	43,500,000	36,000,000	36,000,000	33,500,000	33,400,000	39,900,000
Silver	10,000,000	13,500,000	12,000,000	12,000,000	16,000,000	23,000,000	28,750,000	35,750,000	37,300,000	31,700,000	38,800,000

NOTE.—The silver is calculated at the United States coinage value = $1.2929 per ounce = $41.56 per kilo.

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES, BY STATES, SINCE 1877.

States and Territories.	1877.		1878.		1879.		1880.		1881.		1882.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alaska	....	....	....	....	....	....	$6,000	....	$15,000	....	$150,000	....
Arizona	$300,000	$500,000	$500,000	$3,000,000	$800,000	$3,550,000	400,000	$2,000,000	1,060,000	$7,300,000	1,065,000	$7,500,000
California	15,000,000	1,000,000	15,260,679	2,373,389	17,600,000	2,400,000	17,500,000	1,100,000	18,200,000	750,000	16,800,000	845,000
Colorado	3,000,000	4,500,000	3,366,404	5,394,940	3,225,000	11,700,000	3,200,000	17,000,000	3,300,000	17,160,000	3,360,000	16,500,000
Dakota	2,000,000	....	3,000,000	....	3,420,000	10,000	3,600,000	70,000	4,000,000	70,000	3,300,000	175,000
Georgia	100,000	....	100,000	....	90,000	....	120,000	....	125,000	....	250,000	....
Idaho	1,500,000	250,000	1,150,000	200,000	1,200,000	650,000	1,980,000	450,000	1,700,000	1,300,000	1,500,000	2,000,000
Michigan	....	200,000	....	100,000	....	780,000	....	....	....	....	....	....
Montana	3,200,000	750,000	2,260,511	1,669,635	2,500,000	2,225,000	2,400,000	2,500,000	2,330,000	2,630,000	2,550,000	4,370,000
Nevada	18,000,000	26,000,000	19,546,513	28,130,350	9,000,000	12,560,000	4,800,000	10,900,000	2,250,000	7,060,000	2,000,000	6,750,000
New Mexico	175,000	500,000	175,000	500,000	125,000	600,000	130,000	425,000	185,000	275,000	150,000	1,800,000
North Carolina	100,000	....	150,000	....	90,000	....	95,000	....	115,000	....	190,000	25,000
Oregon	1,000,000	100,000	1,000,000	100,000	1,150,000	20,000	1,090,000	15,000	1,100,000	50,000	830,000	35,000
South Carolina	....	....	....	....	....	....	15,000	....	35,000	....	25,000	....
Texas	....	....	....	....	....	....	....	....	....	....	....	....
Utah	350,000	5,075,000	392,000	5,208,000	575,000	6,250,000	210,000	4,740,000	145,000	6,400,000	190,000	6,800,000
Virginia	50,000	....	....	....	....	....	10,000	....	10,000	....	15,000	....
Washington	300,000	50,000	300,000	25,000	75,000	20,000	410,000	....	120,000	....	120,000	....
Other States	25,000	25,000	25,000	25,000	50,000	47,000	34,000	....	10,000	5,000	5,000	....
Total	$45,100,000	$38,950,000	$47,226,107	$46,726,314	$38,900,000	$40,812,000	$36,000,000	$39,200,000	$34,700,000	$43,000,000	$32,500,000	$46,800,000
Latest Mint estimate	46,900,000	39,800,000	51,200,000	45,200,000	38,900,000	40,800,000	36,000,000	39,200,000	34,700,000	43,000,000	32,500,000	46,800,000

	1883.		1884.		1885.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alaska	$300,000	....	$200,000	....	$300,000	$2,000
Arizona	950,000	$5,200,000	930,000	$4,500,000	880,000	3,800,000
California	14,120,000	1,460,000	13,600,000	3,000,000	12,700,000	2,500,000
Colorado	4,100,000	17,370,000	4,250,000	16,000,000	4,200,000	15,800,000
Dakota	3,200,000	150,000	3,300,000	150,000	3,200,000	100,000
Georgia	199,000	1,000	137,000	....	136,000	... .
Idaho	1,400,000	2,100,000	1,250,000	2,720,000	1,800,000	3,500,000
Michigan	....	....	....	....	....	....
Montana	1,800,000	6,000,000	2,170,000	7,000,000	3,300,000	10,060,000
Nevada	2,520,000	5,430,000	3,500,000	5,600,000	3,100,000	6,000,000
New Mexico	280,000	2,845,000	300,000	3,000,000	800,000	3,000,000
North Carolina	167,000	3,000	157,000	3,500	152,000	3,000
Oregon	660,000	20,000	660,000	20,000	800,000	10,000
South Carolina	56,500	500	57,000	500	43,000	....
Texas	....	....	....	... .	... .	....
Utah	140,000	5,620,000	120,000	6,800,000	180,000	6,750,000
Virginia	6,000	....	2,000	. ...	....	....
Washington	80,000	500	85,000	1,000	120,000	70,000
Other States	21,500	....	82,000	5,000	90,000	5,000
Total	$30,000,000	$46,200,000	$30,800,000	$48,800,000	$31,801,000	$51,600,000
Latest Mint estimate	$30,000,000	$46,200,000	$30,800,000	$48,800,000	$31,800,000	$51,600,000

	1886.		1887.		1888.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alaska	$446,000	$2,000	$675,000	$300	$850,000	$3,000
Arizona	1,110,000	3,400,000	830,000	3,800,000	871,500	3,000,000
California	14,725,000	1,400,000	13,400,000	1,500,000	12,750,000	1,400,000
Colorado	4,450,000	16,000,000	4,000,000	15,000,000	3,758,000	19,000,000
Dakota	2,700,000	425,000	2,400,000	540,000	2,600,000	100,000
Georgia	152,500	1,000	110,000	500	104,000	500
Idaho	1,800,000	3,600,000	1,900,000	3,000,000	2,400,000	3,000,000
Michigan	....	....	26,000	35,000	42,000	84,000
Montana	4,425,000	12,400,000	5,230,000	15,500,000	4,200,000	17,000,000
Nevada	3,090,000	5,000,000	2,500,000	4,900,000	3,525,000	7,000,000
New Mexico	400,000	2,300,000	500,000	2,300,000	602,000	1,200,000
North Carolina	175,000	3,000	225,000	5,000	136,000	3,500
Oregon	990,000	5,000	900,000	10,000	825,000	15,000
South Carolina	37,500	500	50,000	500	39,000	200
Texas	....	200,000	....	250,000	....	300,000
Utah	216,000	6,500,000	220,000	7,000,000	290,000	7,000,000
Virginia	....	....	....	....	....	....
Washington	147,000	80,000	145,000	100,000	145,000	100,000
Other States	5,000	5,000	30,000	500	30,000	500
Total	$34,869,000	$51,321,500	$33,136,000	$53,941,800	$33,167,500	$59,206,700
Latest Mint estimate	$35,000,000	$51,000,000	$33,000,000	$53,350,000	$33,175,000	$59,195,000

	1889.*		1890.		1891.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
Alaska	$904,650	$11,918	$762,500	$9,697	$900,000	$10,343
Arizona	910,174	2,343,977	1,000,000	1,292,929	975,000	1,913,535
California	12,586,722	1,373,807	12,500,000	1,163,636	12,600,000	969,697
Colorado	3,883,859	23,757,751	4,150,000	24,307,070	4,600,000	27,358,384
Dakota	3,091,137	135,331	3,200,000	129,292	3,550,000	129,293
Georgia	107,605	464	100,000	517	80,000	517
Idaho	1,984,159	4,056,482	1,850,000	4,783,838	1,680,000	5,216,970
Michigan	87,040	18,8[illegible]5	90,000	71,111	75,000	94,384
Montana	3,139,327	17,468,960	3,300,000	20,363,636	2,890,000	21,139,394
Nevada	3,506,295	6,072,241	2,800,000	5,753,535	2,050,000	4,551,111
New Mexico	815,655	1,617,578	850,000	1,680,808	905,000	1,713,131
North Carolina	146,795	3,879	118,500	7,757	95,000	6,465
Oregon	964,309	23,382	1,100,000	96,969	1,640,000	297,374
South Carolina	46,853	232	100,000	517	125,000	646
Texas	6,828	418,173	....	387,878	....	484,848
Utah	487,666	9,057,014	680,000	10,343,434	650,000	11,313,131
Virginia	4,100	13	....	....	... .	....
Washington	186,156	36,801	204,000	90,505	335,000	213,334
Other States	27,420	100	40,000	2,585	25,000	4,008
Total	$32,886,744	$66,396,988	$32,845,000	$70,485,714	$33,175,000	$75,416,565
Latest Mint estimate	$32,800,000	$64,646,000	$32,845,000	$70,465,000	$33,175,000	$75,416,000

* *Statistics from the Eleventh Census.*—The Mint figures for 1889 are as follows: Gold—Alaska, $900,000; Arizona, $900,000; California, $13,000,000; Colorado, $3,500,000; Dakota, $2,900,000; Georgia, $107,000; Idaho,

The figures for 1866 are taken from the *Report upon the Mineral Resources of the United States,* by Special Commissioners J. Ross Browne and James W. Taylor, published in 1867. The figures for 1867 are from Commissioner J. Ross Browne's report, 1868, and those for 1868 are from the first report by Dr. R. W. Raymond on *Mineral Resources of the States and Territories West of the Rocky Mountains,* published in 1869. The figures for the years 1869 to 1875 are from Dr. Raymond's eighth and last report, published in 1876. They are given as estimates made from the best attainable authorities. In many cases he accepts the estimates of Wells, Fargo & Co., but in other cases he rejects them in favor of figures obtained from other sources. The figures for the years subsequent to 1875 are those of the Director of the Mint, with the exception of 1889, which are those compiled by the Eleventh Census.

The production of gold and silver in the United States in 1892 is shown in the following table:

	* Product of Refineries.	* Exported in Copper Matte.	* Deposits of Unrefined Bullion at Mints.	Total.
Gold..............	913,556 oz.	9,262 oz.	673,698 oz.	1,596,516 oz.
Silver........ . . .	60,009,136 oz.	1,572,931 oz.	3,317 933 oz.	64,900,000 oz.

* All of domestic origin.

UNITED STATES: IMPORTS AND EXPORTS OF GOLD AND SILVER IN COIN AND BULLION.

Year.	Gold.		Silver.		Year.	Gold.		Silver.	
	Exports.	Imports.	Exports.	Imports.		Exports.	Imports.	Exports.	Imports.
1870..	$53,103,745	$10,430,561	$27,846,083	$15,259,199	1882..	$38,721,079	$13,402,528	$17,317,055	$9,098,385
1871..	44,915,975	5,841,948	32,524,495	10,962,467	1883..	6,048,770	22.055.961	25,794,670	14,153,357
1872..	68,638,125	11,113,290	32,048,799	10,068,714	1884..	40,948,246	27,957,657	29,563,748	15,504,777
1873..	25,496.118	20.537,254	38,076,207	9,212,185	1885..	11,417,207	23,642,826	33,280,542	17,771,241
1874..	43,149,091	7,422,806	29,577,984	7,830,998	1886..	41,281,276	41,309,181	27,040,290	17,221,465
1875 .	53,413,947	14,348,781	25,889,567	8,547 367	1887..	9,144,426	44,889,299	27,644,988	16.772,614
1876..	31,231,739	23,676,096	25,122,736	10,795,238	1888..	34,526,449	10.960,773	29,880,403	15,907,969
1877	18,982,638	11,629,655	29,336,929	12,141,560	1889..	50,933,460	12,004,632	40,694,230	19,219,262
1878..	8,655,948	10,477,859	18,209,252	18,389.884	1890..	24,063,074	20,230,090	26,539,789	22,426,119
1879..	4,115,446	78,767,941	21,701,552	14,425,017	1891..	79,086,581	44,970,110	27,692,879	18,192,750
1880..	3,062.459	73,644,698	12,983,442	11,631,025	1892..	76,496,470	17,450,946	35,975,834	21,726,252
1881..	2,603,543	60,398,620	17.063,274	8,595,645					

UNITED STATES: IMPORTS AND EXPORTS OF GOLD AND SILVER IN ORES.*

Year.	Gold.		Silver.	
	Imports.	Exports.	Imports.	Exports.
1887...	$14,028	$87,604	$4,228,107	$924,105
1888...	71,168	125,153	5,684,093	637,766
1889...	56,8 8	14.813	7,580,196	629,000
1890...	149,366	32,094	8,356,412	1,126,697
1891...	233,269	100,918	9,717,443	1,090,514
1892...	714,110	9,262	9,724,716	1.592,931

* The imports of gold and silver given in the above tables are taken from official sources. The exports are only approximately correct. The Bureau of Statistics reports only the value of "silver ores" exported, but a much larger amount of silver leaves the country in copper matte, which is classified as "copper ore," and no record is kept of its silver contents. In the above table the value of the silver in copper matte, so far as could be obtained from the reports of the Director of the Mint, has been added to the value of silver ores, values being calculated at the commercial rates each year. The gold in copper matte exported is not included in the exports of gold given in the above table.

$2,000,000; Michigan, $70,000; Montana, $3,500,000; Nevada, $3,000,000; New Mexico, $1,000,000; North Carolina, $145,000; Oregon, $1.200,000; South Carolina, $45,000; Utah, $500,000; Washington, $175,000; other States, $25,000; total, $32,967,000. Silver—Alaska, $10,343; Arizona, $1,939,393; California, $1,034,343; Colorado, $20,686,868; Dakota, $64,646; Georgia, $465; Idaho, $4,395,959; Michigan, $77,575; Montana, $19,393,939; Nevada, $6,206,060; New Mexico, $1,461,010; North Carolina, $3,878; Oregon, $38,787; South Carolina, $232; Texas, $300,000; Utah, $9,050,505; Washington, $103,434; other States, $1,293—total, $64,768,730. The latest Mint estimates for 1889 are: Gold, $32,800,000; silver, $64,646,000.

COINAGE OF THE MINTS OF THE UNITED STATES.

Years.	Gold.	Silver.	Years.	Gold.	Silver.	Years.	Gold.	Silver.
1793-1795...	$71,485 00	$370,683 80	1828....	$140,145 00	$1,575,600 00	1861....	$83,395,530 00	$3,783,740 00
1796........	77,960 00	77,118 50	1829....	295,717 50	1,994,578 00	1862....	20,875,997 50	1,252,516 50
1797........	128,190 50	14,550 45	1830....	643,105 00	2,495,400 00	1863....	22,445,482 00	809,267 80
1798........	205,610 00	330,291 00	1831....	714,270 00	3,175,600 00	1864....	20,081,415 00	609,917 10
1799........	213,285 00	423,515 00	1832...	798,435 00	2,579,000 00	1865....	28,295,107 50	691,005 00
1800........	317,760 00	224,296 00	1833....	978,550 00	2,759,000 00	1866....	31,435,945 00	982,409 25
1801........	422,570 00	74,758 00	1834....	3,954,270 00	3,415,002 00	1867....	23,828,625 00	908,876 25
1802........	423,310 00	58,343 00	1835....	2,186,175 00	3,443,003 00	1868..	19,371,387 50	1,074,343 00
1803........	258,377 50	87,118 00	1836....	4,135,700 00	3,606,100 00	1869...	17,582,987 50	1,266,143 00
1804........	258,642 50	100,340 50	1837....	1,148,305 00	2,096,010 00	1870....	23,198,787 50	1,378,255 50
1805........	170,367 50	149,388 50	1838....	1,809 765 00	2,333,243 40	1871...	21,032,685 00	3,104,038 30
1806........	324,505 00	471,319 00	1839....	1,376,847 50	2,209,778 20	1872....	21,812,645 00	2,504,488 50
1807........	437,495 00	597,448 75	1840....	1,675,482 50	1,726,703 00	1873....	57,022,747 50	4,024,747 60
1808........	284,665 00	684,300 00	1841....	1,091,857 50	1,132,750 00	1874....	35,254,630 00	6,851,776 70
1809........	169,375 00	707,376 00	1842...	1,829,407 50	2,332,750 00	1875....	32,951,940 00	15,347,893 00
1810........	501,435 00	638,773 50	1843...	8,108,797 50	3,834,750 00	1876....	46,579,452 50	24,503,307 50
1811........	497,905 00	608,340 00	1844...	5,427,670 00	2,235,550 00	1877....	43,999,864 00	28,393,045 50
1812........	290,435 00	814,029 50	1845....	3,756,447 50	1,873,200 00	1878....	49,786,052 00	28,518,850 00
1813........	477,140 00	620,951 50	1846....	4,034,177 50	2,558,580 00	1879....	39,080,080 00	27,569,776 00
1814........	77,270 00	561,687 50	1847....	20,202,325 00	2,374,450 00	1880....	62,308,279 00	27,411,693 75
1815........	3,175 00	17,308 00	1848....	3,775,512 50	2,040,050 00	1881..	96,850,890 00	27,940,163 75
1816........	....	28,575 75	1849...	9,007,761 50	2,114,950 00	1882....	65,887,685 00	27,973,132 00
1817........	....	607,783 50	1850....	31,981,738 50	1,866,100 00	1883....	29,241,990 00	29,246,958 45
1818........	242,940 00	1,070,454 50	1851....	62,614,492 50	774,397 00	1884..	23,991,756 50	28,534,866 15
1819........	258,615 00	1,140,000 00	1852....	56,846,187 50	999,410 00	1885....	27,773,012 50	28,962,176 20
1820........	1,319,030 00	501,680 70	1853....	39,377,909 00	9,077,571 00	1886....	28,945,542 00	32,086,709 90
1821........	189,325 00	825,762 45	1854....	25,915,962 50	8,619,270 00	1887....	23,972,383 00	35,191,081 40
1822........	88,980 00	805,806 50	1855....	29,387,968 00	3,501,245 00	1888...	31,380,808 00	33,025,606 45
1823........	72,425 00	895,550 00	1856....	36,857,768 50	5,142,240 00	1889...	21,413,931 00	35,496,683 15
1824........	93,200 00	1,752,477 00	1857...	32,214,040 00	5,478,760 00	1890....	20,467,183 00	39,202,908 00
1825........	156,385 00	1,564,583 00	1858....	22,938,413 50	8,495,370 00	1891...	29,222,005 00	27,518,857 00
1826........	92,245 00	2,002,090 00	1859....	14,780,570 00	3,284,450 00	1892...	34,787,222 50	12,641,078 00
1827........	131,565 00	2,869,200 00	1860....	23,473,654 00	2,259,390 00			

Production of Gold and Silver in Foreign Countries.

Australia.—All the colonies of Australia, together with Tasmania and New Zealand, produce gold, Queensland leading at the present time, followed by Victoria, New Zealand, and New South Wales, in the order named.

The chief gold-producing districts of Queensland are Charter Towers, Rockhampton (where the Mount Morgan mine is the principal producer), Croydon, and Gympie. Nearly the entire amount of gold produced is derived from the quartz mines, the placers having been practically exhausted. The decline in the latter and the rise in the former is shown in the following table:

PRODUCTION OF GOLD IN QUEENSLAND SINCE 1877.

Year.	Alluvial, Ounces.	Quartz, Ounces.	Total, Ounces.	Year.	Alluvial, Ounces.	Quartz, Ounces.	Total, Ounces.
1877.....	164,778	188,488	353,266	1885..	21,936	289,005	310,941
1878.....	130,574	179,038	309,612	1886.....	15,361	325,637	340,998
1879.....	107,402	181,154	288,556	1887.....	21,700	404,233	425,923
1880.....	86,082	181,054	267,136	1888.....	12,099	469,544	481,643
1881.....	70,821	200,134	270,955	1889.....	10,287	728,816	739,103
1882.....	52,038	172,855	224,893	1890.....	19,069	591,518	610,587
1883.....	35,327	177,460	212,787	1891.....	16,021	560,418	576,439
1884.....	26,175	281,629	307,804				

The total production of gold in the principal districts of the colony is given in the following table:

PRODUCTION OF GOLD IN QUEENSLAND, BY DISTRICTS.

Year.	Charter Towers, Ounces.	Gympie, Ounces.	Ravenswood, Ounces.	Rockhampton, Ounces.	Palmer, Ounces.	Etheridge, Ounces.	Croydon, Ounces.	Eidsvold, Ounces.
1877*	599,000	625,000	201,400	....	839,000	143,000	....	....
1878	72,189	41,564	13,252	....	120,233	7,396	....	....
1879	83,275	38,453	15,744	....	90,000	15,498	....	....
1880	85,298	43,072	13,445	....	65,433	20,368	....	....
1881	82,324	67,861	10,195	....	51,960	23,020	....	....
1882	79,595	50,312	8,711	....	37,339	18,431	....	....
1883	69,555	64,818	13,000	4,194	24,089	18,967	....	....
1884	109,335	112,051	14,192	22,158	15,637	19 886	....	....
1885	135,650	89,600	17,641	14,396	12,913	28,348	....	....
1886	144,370	88,600	9,245	49,086	8,587	25,629	2,144	....
1887	151,377	102,149	10,390	85,305	6,981	21,036	31,788	....
1888	137,522	107,119	10,666	117,800	16,424	24,647	44,862	7,007
1889	165,552	115,590	15,719	325,683	16,861	18,285	52,541	15,596
1890	164,022	78,366	16,053	226,240	10,689	24,580	60,368	15,933
1891	223,403	60,714	13,427	147,691	12,721	17,908	65,892	10,732
Total	2,302,476	1,685,269	383,080	992,553	1,328,867	426,999	257,595	49,268

* Including 1877 and previous years.

The production of gold in Queensland during the first nine months of 1892 was 442,139 ounces, of which Charter Towers yielded 186,062 ounces; Rockhampton, 92,415; Gympie, 59,767; and Croydon, 47,583. The total yield for 1892 will probably be about 30,000 ounces more than in 1891. The great Mount Morgan mine is on the decline; in fact, it is said that the mine has been "bottomed," though it still contains large quantities of low-grade ore.

The production of gold in Victoria has been gradually declining since 1856, owing to the exhaustion of the alluvial deposits, although the yield of the quartz mines has been increasing. At the present time about 67% of the gold of Victoria is derived from quartz mines and 33% from placers. There are seven gold-producing districts in the colony—Ballarat, Sandhurst (Bendigo), Beechworth, Maryborough, Castlemaine, Gippsland, and Ararat, which are of importance in the order named. Beechworth and Sandhurst are the only districts that had increased yields in 1891, and it is noteworthy that more than 96½% of the gold from the latter place came from lode mines, ten of which are opened to a depth of more than 2000 ft. The past year has witnessed a revival in mining at Bendigo, and the output of that district has been much larger than in 1891. The yield of this famous old field since it was opened in October, 1851, is officially stated as follows:

PRODUCTION OF GOLD AT BENDIGO.

Year.	Ounces.	Year.	Ounces.	Year.	Ounces.	Year.	Ounces.
1851	200,000	1856	609,729	1861	298,442	1866	212,304
1852	475,857	1857	492,431	1862	231,514	1867	221,552
1853	661,749	1858	447,712	1863	199,810	1868	217,016
1854	429,983	1859	403,891	1864	192,617	1869	225,258
1855	451,588	1860	346,603	1865	180,961	1870	241,380

Year.	Gold, Ounces.	Calls.†	Dividends.†	Year.	Gold, Ounces.	Calls.†	Dividends.†
1871	279,719	£232,421	£434,276	1882	202,269	£208,260	£333,472
1872	360,300	360,300	683,140	1883	220,158	196,395	320,731
1873	329,447	234,066	628,066	1884	219,160	154,697	318,048
1874	313,965	188,384	500,615	1885	216,772	131,530	286,366
1875	295,007	110,859	342,865	1886	177,546	133,721	191,321
1876	275,208	104,007	404,695	1887	163,010	131,794	134,920
1877	183,049	67,969	143,015	1888	174,581	172,055	178,799
1878	168,990	61,182	204,325	1889	148,703	137,489	118,473
1879	172,252	59,698	169,635	1890	155,091	111,142	149,381
1880	172,629	83,793	214,552	1891	145,556	114,870	148,183
1881	169,964	202,909	250,717	1892*	134,203	91,103	169,667

* Thirty-seven weeks. † Since 1871 the calls and dividends have been contrasted.

This gives a total of 11,417,697 oz., which at £4 per oz. represents £45,670,788. But it is known that much of the gold (especially that obtained in the earlier years of the diggings) was carried away privately to Melbourne, Sydney, Geelong, Adelaide, and other places by the parties who obtained it, and it is estimated that this amount exceeded 4,000,000 oz. The total value of the gold obtained from Bendigo, therefore, may be set down at $300,000,000.

The following statement from the annual report of the Secretary for Mines, 1891, shows the estimated average value of gold produced in Victoria, per miner employed, in each of the years from 1860 to 1891, inclusive:

Year.	Average.	Year.	Average.	Year.	Average.	Year.	Average.
	£ s. d.		£ s. d.		£ s. d.		£ s. d.
1860	79 9 3	1868	104 18 8	1876	89 19 6	1884	106 14 6
1861	74 15 11	1869	79 7 0	1877	82 6 1	1885	108 15 9
1862	67 14 5	1870	81 0 6	1878	82 12 11	1886	104 18 3
1863	70 9 0	1871	93 6 0	1879	76 1 2	1887	96 17 2
1864	74 1 9	1872	93 17 1	1880	81 18 11	1888	97 8 7
1865	74 4 2	1873	93 16 2	1881	95 11 9	1889	101 2 2
1866	80 8 3	1874	99 8 3	1882	95 19 7	1890	98 15 7
1867	87 1 6	1875	104 4 4	1883	95 6 3	1891	97 0 6

The average yield of gold per ton of quartz crushed in Victoria in each year of the last decade has been as follows: *

Year.	Quartz Crushed.	Gold Obtained	Average.	Year.	Quartz Crushed.	Gold Obtained	Average.	Year.	Quartz Crushed.	Gold Obtained	Average.
	tons.	ounces.	oz. dwt. gr.		tons.	ounces.	oz. dwt. gr.		tons.	ounces.	oz. dwt. gr
1882..	1,027,826	463,463	0 9 0	1886..	831,375	391,988	0 9 10	1889..	732,461	358,893	0 9 19
1883..	924,430	440,686	0 9 12	1887..	780,733	367,519	0 9 9	1890..	752,398	346,158	0 9 4
1884..	876,692	432,996	0 9 21	1888..	734,313	357,928	0 9 17	1891.	772,964	355,715	0 9 4
1885..	843,250	423,879	0 10 1								

Victoria has no silver mines. The quantity of silver extracted from gold in 1891 at the Melbourne mint was 30,039 oz.

The most important gold-fields of New South Wales are Peel and Uralla, Lachlan, Bathurst, and Mudgee, the more part of the product of the colony coming from its quartz mines. During the past four or five years the output has been increasing, and there is reason to believe that these fields will continue to make a large yield. No effective and economical method of treating the pyritous ores has yet been introduced in the colony, nor has water been brought to bear on any extensive scale upon the auriferous deposits known to exist along some of the river banks.†

New South Wales is the largest silver producing colony of Australia, the output of the other colonies being comparatively insignificant. The ore raised is for the most part silver-lead, coming chiefly from the Broken Hill, Silverton, and Sunny Corner districts. The yield of the Barrier Range (Broken Hill) mines during the past year amounted to 11,801,446 oz., notwithstanding the labor difficulties which caused a suspension of work for 18 weeks. The production of this district in 1892, by companies, is given in the following table:

SILVER AND LEAD PRODUCTION OF THE BARRIER MINES IN 1892.

	Block 10.	Block 14.	British.	Broken Hill Cons.	Central.	Junction.	Junction N.	Proprietary.	South.	Total.
Ore treated, tons	14,776	46,168	23,205	......	26,102	2,330	87	200,332	16,873	389,873
Lead produced, tons	127	11,313	4,015	......	2,091	280	.....	36,330	2,447	56,633
Copper produced, tons.	20	25	20	.. ..	79	......	.. ..	275	129	548
Silver contents, ozs	2,037,284	1,472,563	2,214,262	17,090	813,184	54,122	3,030	8,280,364	445,000	13,336,809
Dividends declared	$1,187,500	$262,500	.....	......	$37,500	......	.....	$3,360,000	.. .	$969,500

* These statements do not show the total quantity of quartz crushed, but only the yield from certain crushings respecting which the Mining Registrars have been able to obtain information.

† *Annual Report of the Department of Mines and Agriculture*, New South Wales, 1891.

PRODUCTION OF GOLD IN AUSTRALASIA FROM 1851.

Year.	New South Wales.		Victoria.		New Zealand.		Queensland.		Tasmania.		South Australia.		Western Australia.		Total Production.		Total Value.
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces	Value.	Ounces	Value.	Ounces	Value.	Ounces.	Kilos.	
		£		£		£		£		£		£		£			$
1851	144,120	468,336	212,899	851,596	....	....	....	....	....	....	....	....	....	....	356,919	11,119	6,414,869
1852	818,751	2,660,946	2,286,535	9,146,140	....	....	....	....	....	....	....	....	....	....	3,105,286	96,738	57,382,438
1853	548,052	1,781,172	2,744,098	10,976,392	....	....	....	....	....	....	....	....	....	....	3,292,150	102.559	62,001,761
1854	237,910	773,209	2,218,483	8,873.532	....	....	....	....	....	....	....	....	....	....	2,456,393	76.521	45,083,161
1855	171,367	654,594	2,819,288	11,277,152	....	....	....	....	....	....	....	....	....	....	2,990,655	93,166	58,474,289
1856	184,600	689,174	3,053.744	12,214,976	....	....	....	....	....	....	....	....	....	....	3,238,344	100.889	50,722,169
1857	175,949	674,477	2,830,213	11.320,852	10,437	40,422	....	....	....	....	....	....	....	....	3,016,599	93,975	58,493.750
1858	286,798	1,104,175	2,596,231	10,384,924	13,534	52,464	....	....	....	....	....	....	....	....	2,896,563	90,235	56,091,996
1859	329,363	1,259,127	2,348,703	9,394,812	7,336	28,427	....	....	....	....	....	....	....	....	2,685,402	83,657	51,916,299
1860	384,053	1,465,373	2,224,069	8,896,276	4,538	17,585	....	....	....	....	....	....	....	....	2,612,660	81.391	50,443,077
1861	465.685	1,806,172	2,035,173	8,140.692	194,031	751,873	....	....	....	....	....	....	....	....	2,694.889	83,953	51,995,862
1862	640,622	2,467,780	1,730,201	6,920,804	410,862	1,591,389	....	....	....	....	....	....	....	....	2,781,685	86.656	53,362.669
1863	466,111	1,796,170	1,694,819	6,779.276	628,450	2,431,723	....	....	....	....	....	....	....	....	2.789,380	86,896	53,494,829
1864	340,267	1,304,926	1,622,447	6,489,788	480,171	1,856,837	....	....	....	....	....	....	....	....	2,442,885	76,102	46.905,566
1865	320,316	1,231,243	1,611,554	6 446,216	574,574	2.226,474	....	....	....	....	....	....	....	....	2,506,444	78.082	48,133,114
1866	290,014	1,116,404	1,546,948	6,187,792	735,376	2,844,517	....	....	348	1,392	....	....	....	....	2,572,686	80,146	49,329,510
1867	271,886	1,053,578	1,501,446	6,005,784	686,905	2,698,862	....	....	1,363	5,392	....	....	....	....	2,461,600	76,685	47,451,174
1868	255 662	994,665	1,684,918	6,739,672	637,474	2,504.326	....	....	692	2,768	....	....	....	....	2,578,746	80,334	49,773,355
1869	251,491	974,149	1,544,756	6,179.024	614,281	2,362,995	....	....	137	548	....	....	....	....	2,410,685	75,099	46,251,240
1870	240,858	931,016	1,304,304	5,217,216	544,880	2,157,585	....	....	964	3,856	....	....	....	....	2,091.006	65,140	40,385,011
1871	323,609	1,250,485	1,368,942	5,475,768	730,029	2,787,520	....	....	6,005	24,020	....	....	....	....	2,428.585	75,657	46,450,874
1872	425,129	1.643,582	1,331,377	5.325,508	445,370	1,731,261	....	....	6,969	27,876	2,494	8,729	....	....	2,211,339	68,889	42,461,606
1873	361,784	1,395,175	1,170,397	4,681,588	505.337	1,987,425	....	....	4,661	18,644	98	343	....	....	2,042,277	63,622	39,284,230
1874	270,823	1.040,329	1,097,643	4,390.572	376.388	1,505,331	....	....	4,650	18,600	8,351	29,229	....	....	1,757.855	54,761	33,942,536
1875	230,882	877,694	1,068,417	4,273,668	355.322	1,407,770	....	....	3,010	12,040	13,742	48,097	....	....	1,671,373	52,067	32,169.647
1876	167,411	613,190	963,760	3,855,040	322,016	1,284,328	....	....	11,107	44,428	9,857	34,500	....	....	1,474,151	45,923	28,339,078
1877	124,110	471,418	809,653	3,238,612	371,685	1,496,080	2,646,916	9,264,206	5,777	23,108	11,811	41,339	....	....	3,969,952	123,674	70,640,893
1878	119,665	430,033	758,040	3,032.160	310,486	1,240,079	310,247	1,085,864	25,249	100,996	10,745	37,608	....	....	1,534,432	47,801	28,803.937
1879	109,649	407,219	758,947	3,035,788	287,464	1,148,108	288,556	1,009,946	60,155	240,620	14,250	49,875	....	....	1,519,021	47,321	28,632,962
1880	118,600	441,543	829,121	3,316,484	305,248	1,227,252	267,136	934,976	52,595	210,380	13,245	46,358	....	....	1,585,945	49,406	30,020,186
1881	149,627	566,513	833,378	3,333.512	270,561	1,080,790	270,945	948,308	56,693	226.772	16,975	59,413	....	....	1,598,179	49,787	30,206,397
1882	140,469	526,522	864,610	3,458,440	251,204	1,002.720	224,893	787,125	49,122	196,488	15,668	54,838	....	....	1,545,966	48,161	28,807,006
1883	123,805	458,509	780,253	3,121,012	248,374	993,352	212,783	744,741	46,577	186.308	15,938	55,783	....	....	1,427,930	44,483	27,020,166
1884	107,198	395,292	778,618	3,114,472	229,946	921,797	307,804	1,077,314	42,339	169,656	21,454	75,089	....	....	1,487,359	46,335	27,962,593
1885	103,736	378,665	735,218	2,940,872	237.371	948,615	310.941	1,088,293	37,317	149.268	18,327	64,145	....	....	1,442,910	44,950	27,059,693
1886	101,416	366,294	665,196	2,660,784	227.079	903,569	340,998	1,193,493	31.014	124.056	21,115	73,903	....	....	1,386,818	43,203	25,865,401
1887	110,288	394.579	617,751	2,471,004	203,869	811,100	425,923	1,490,731	31,861	127,444	31,745	111,108	4,873	19,492	1,426,310	44,433	26,367,726
1888	87,503	317,100	625,026	2,500,104	201,219	801,066	481,643	1,685,750	39.610	158,440	16,763	58,671	3,493	13,098	1,454,657	45,316	26,896,353
1889	119,759	434,070	614,838	2,459,352	203,211	808,549	739,103	2,586,861	33.050	132.200	20,000	70,000	15,492	58,871	1,745,453	54,375	31,832,529
1890	127,760	460,285	588,560	2,354.240	193,193	773,438	610,587	2,137,054	23.451	93,804	26,086	91,301	22,256	86,664	1,591,893	49,591	29,144,380
1891	153,336	558,306	576,399	2,305,59[illegible]	251,996	1,007,448	576,439	2,017,537	48,769	195,076	28,700	100,450	30,311	115,182	1,465,950	45,668	30,614,088
Tot'l	10.373,452	38.633.489	57,446,973	229,787,892	12.070,217	47.433.077	8,014,914	28,052,199	620,485	2,474,080	317,364	1.110,779	76,425	293.307	88,919.830	2,770,087	1,690,137,137

NOTE.—The values of the annual gold product of New South Wales, New Zealand. and Western Australia are taken from the blue-books of the mining departments of these colonies. The mines departments of Queensland and Victoria state amounts only in their returns. The values of the yearly products of these colonies have, together with those of Tasmania and South Australia, therefore, been calculated at £4 per ounce for Victoria and Tasmania, and £3 10s. per ounce for Queensland and South Australia. The Queensland returns have been compiled annually since 1877 only. The figures for this colony for the year 1877, in the above table, represent the product of the gold mines from the beginning to the end of that year. There are no reliable statistics of the production of gold in South Australia, and the figures given represent only the amount of gold from that colony received at the Melbourne mint.

The production of the Broken Hill Proprietary Company from the beginning of its operations to May 30, 1892, is reported officially as follows:

BROKEN HILL PROPRIETARY MINING COMPANY, LIMITED.

Year.*	Tons Treated.	Tons Lead.	Ounces Silver.	Year.*	Tons Treated.	Tons Lead.	Ounces Silver.
1885	48	....	35,605	1890	207,311	30,339	7,727.877
1886	11,500	1.991	1,016.260	1891	286,118	41,688	9,947,038
1887	47.211	9,348	2,103,225	1892	200,332	36,330	8,280,364
1888	94,125	16,659	3,924.192				
1889	157,184	25,076	6,003,299	Total	1,003,829	161.431	39.039,869

* Fiscal years ending Nov. 30.

The colonies of South and Western Australia are as yet but small producers of gold, though they contain several promising gold-fields and deposits of silver-lead ore, which are gradually being opened.

In New Zealand gold is won both from alluvial and lode mines, the former confined entirely to the Middle Island, while in the North Island quartz lodes only are being worked.* There are but two mines in the North Island and three in the Middle Island which have reached a depth exceeding 500 ft. The most important gold-fields are the Kuaotuna, Thames, Coromandel, Waihi, and Reefton in the North Island, and Ross and Kumara in the Middle Island. The silver product of New Zealand is insignificant.

The production of the precious metals in Tasmania is still small, but this island is regarded as one of the most valuable mineral divisions of Australasia. Promising silver mines have been discovered recently at Mount Zeehan and Dundas, but the country is so rough and so heavily timbered that communication is difficult and its development will be slow.

Austria-Hungary.—The small quantity of gold which is produced in Austria comes chiefly from Rathhausberge, in Salzburg, and from the antimony mines of Kuttenberg, in Bohemia, where gold is extracted as a by-product. Silver occurs chiefly in the "grauwacke" of Pribram, in Bohemia. The chief ore is argentiferous galena, which carries from 0.12% to 0.8% silver, besides which occur what are known as the "dürrerze" (silver ores finely disseminated in quartz gangue), which carry from 0.07% to 0.25% silver. The zincblende, which is mined in large quantities, also contains silver. The average contents of the ore delivered to the smelting works are 0.25% silver and about 30% lead. Besides the Pribram smelting works, those of Brixlegg, in the Tyrol, and Littai, in Carinthia, produce a certain amount of silver. In the latter works the ores smelted are of foreign origin.

In Hungary gold and silver are found chiefly in the districts of Schemnitz, Kremnitz, Nagybáya, Szomolnok, Oravicza, Abrudbanya, and Zalatua. In Schemnitz and Kremnitz the lodes occur in eruptive rocks of Tertiary age, chiefly in greenstone-trachyte (propylite), porphyry of different kinds, diorite, and granite. The most common ore in Schemnitz is argentiferous galena, zincblende, and pyrites. A red-brown auriferous quartz characteristic of the district impregnated with galena, blende, and pyrites, is locally called "sinopel." The Schemnitz

* *Reports on the Mining Industries of New Zealand*, 1891.

lodes are chiefly silver-bearing, and carry from 300 to 500 grams "güldish-silver" per centner of 100 kilos. The Kremnitz ores carry gold and silver in the proportion of 1:3. Gold is found in considerable quantity in Transylvania, where the lodes all occur in eruptive rocks of Tertiary age, chiefly in greenstone-trachyte, porphyry, diorite, and granite.

PRODUCTION OF GOLD AND SILVER IN AUSTRIA-HUNGARY.*

Years.	Gold.		Silver.		Years.	Gold.		Silver.	
	Kilos.	Value.	Kilos.	Value.		Kilos.	Value.	Kilos.	Value.
1493–1520	2,000	$1,329,200	24,000	$997,624	1856–1860	1,560	$1,036,775	31,700	$1,317,695
1521–1544	1,500	996,900	32,000	1,330,166	1861–1865	1,690	1,123,173	36,500	1,517,220
1545–1560	1,000	664,600	30,000	1,247,030	1866–1870	1,650	1,096,590	39,970	1,661,460
1561–1580	1,000	664,600	23,500	976,840	1871–1875	1,395	927,116	38,550	1,602,434
1581–1600	1,000	664,600	17,000	706,651	1876	1,903.6	1,265,133	47,947	1,992,677
1601–1620	1,000	664,600	11,000	457,244	1877	1,713.4	1,138,726	47,675	1,982,073
1621–1640	1,000	664,600	8,000	332,541	1878	1,824.1	1,212,297	48,662	2,022,393
1641–1660	1,000	664,600	8,000	332,541	1879	1,610.6	1,070,405	48,195	2,002,984
1661–1680	1,000	664,600	10,000	415,677	1880	1,645.4	1,093,533	47,701	1,982,454
1681–1700	1,000	664,600	10,000	415,677	1881	1,597.3	1,061,565	48,942	2,034,024
1701–1720	1,000	664,600	10,000	415,677	1882	1,740.8	1,156,936	47,663	1,980,879
1721–1740	1,000	664,600	12,500	519,596	1883	1,638	1,088,000	48,700	2,024,000
1741–1760	1,000	664,600	24,000	997,624	1884	1,658	1,102,000	49,300	2,049,000
1761–1780	1,000	664,600	24,000	997,624	1885	1,774	1,179,000	52,748	2,192,200
1781–1800	1,280	850,687	26,000	1,080,760	1886	1,806	1,201,935	51,739	2,150,289
1801–1810	960	638,015	29,500	1,226,246	1887	1,877	1,247,450	53,391	2,218,900
1811–1820	1,000	664,600	25,000	1,039,192	1888	1,820	1,209,572	52,128	2,166,443
1821–1830	1,135	754,320	21,000	872,921	1889	2,198	1,461,000	52,651	2,188,000
1831–1840	1,625	1,079,974	20,040	833,016	1890	2,104	1,398,500	50,613	2,103,500
1841–1850	1,950	1,295,969	30,600	1,271,971	1891	†2,104	†1,398,500	†50,613	†2,103,500
1851–1855	1,775	1,179,664	35,000	1,454,869					

* The figures for the years 1493–1875 are from Soetbeer's *Edelmetall Produktion*; 1876–1882, from Soetbeer's *Materialen*; 1883–1890, from reports of the Director of the Mint, *Production of Gold and Silver in the United States*. † Estimated the same as officially reported for 1890.

NOTE.—Values for years 1883-1890 are estimated at United States coining rate, viz., kilogram of gold, $664.60; kilogram of silver, $41.56.

British India.—Practically the entire gold production of British India at the present time comes from the Presidency of Madras and the Province of Mysore, chiefly the latter. The gold-fields of Colar, Mysore, in Southern India, first began to attract attention in 1880, and three of the principal enterprises now operating there were organized during that year; these were the Mysore, Ooregum, and Nundydroog companies, the Balaghât-Mysore not having been registered until 1886. Up to 1885 the production of the new field was trivial, but in that year it underwent a notable expansion, and since then has been increasing steadily.

The Colar gold-field lies about 40 miles east of Bangalore, on a vast plain covered with grass and scrub. The geological formation is a granitic gneiss, passing into syenitic or hornblendic varieties, traversed north and south by a band of greenstone trap about two miles in width. It is in this trap-rock that the auriferous reefs occur. It varies in structure from coarsely crystalline diorite to fine-grained greenstone, the productive quartz reefs being found invariably in the fine-grained rock. The ore is free-milling and of good grade, but occurs in comparatively narrow veins, which have, however, been opened to considerable depths with good results, as the monthly returns of the crushings show. At the end of November last the main shaft of the Mysore mine had attained a depth of 1200 ft.

The production of gold in the Presidency of Madras is insignificant, amounting to less than 2000 oz. annually. Gold has been found in many parts of British India, and the wealth of the country in the precious metals in the past is a matter of history. The Colar field of Mysore promises to maintain its output, and it is not unlikely that new finds will be made in the empire which will make it a more important producer of gold.

PRODUCTION OF GOLD IN BRITISH INDIA.

Year.	Mysore.		Madras.		Total.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
1884	1,135	$21,535	....	....	1,135	$21,535
1885	6,150	116,587	....	....	6,150	116,587
1886	16,042	302,822	....	....	16,042	302,822
1887	14,930	282,939	1,715	$32,557	16,645	315,496
1888	31,330	650,866	1,320	25,010	32,650	675,876
1889	78,345	1,382,855	2,656	45,145	81,001	1,427,999
1890	107,079	1,872,150	1,694	31,274	108,773	1,903,424
1891	130,338	2,446,621	1,700	21,396	132,038	2,478,017
1892	156,382	2,955,620	1,700	31,396	158,082	2,987,016
Total	541,731	10,031,995	10,785	186,778	5.525.516	10,528,732

NOTE.—The figures for 1884–88 are from reports of the Director of the Mint on the production of gold and silver in the United States; 1889 and 1890 are official returns; 1891 and 1892 are calculated from the monthly yield of the producing mines in the Colar field, estimating the output of the Madras Presidency the same as in 1890. Where not given otherwise, values have been calculated at the rate of £3 17*s.* 9*d.* per ounce.

BRITISH INDIA: IMPORTS AND EXPORTS OF GOLD AND SILVER AND COINAGE OF SILVER.

Year.	Gold.		Silver.			Year.	Gold.		Silver.		
	Imports.	Exports.	Imports.	Exports.	Coinage.		Imports.	Exports.	Imports.	Exports.	Coinage.
	$	$	$	$	$		$	$	$	$	$
1851	5,776,550	10,080	13,282,490	2,696,365	13,082,090	1872	17,868,890	42,170	40,000,175	7,338,300	8,451,970
1852	6,693,890	355,825	18,566,400	4,239,615	21,202,480	1873	13,111,855	345,045	9,671,070	6,095,350	19,904,570
1853	6,705,530	844,025	22,451,135	4,426,015	27,549,820	1874	8,244,040	1,330,845	20,718,630	8,239,510	11,850,030
1854	5,393,540	86,325	18,853,415	7,324,495	26,267,178	1875	10,446,180	1,078,505	30,259,055	7,048,040	24,484,420
1855	4,413,605	757,155	5,725,685	5,577,685	6,829,510	1876	9,181,905	1,456,250	17,321,705	9,544,930	12,751,090
1856	12,541,765	10,540	43,963,965	2,992,090	34,868,295	1877	7,218,560	6,181,810	49,962,040	13,967,680	31,355,610
1857	10,880,010	423,940	61,188,475	5,322,240	53,896,465	1878	7,894,635	5,553,990	70,882,660	5,500,990	80,901,630
1858	1,415,042	235,055	64,926,660	3,831,920	62,757,010	1879	7,315,250	11,246,115	27,968,495	8,115,025	36,053,850
1859	22,186,695	54,430	4,189,846	3,256,750	32,589,935	1880	10,251,965	1,499,445	48,025,010	8,676,295	51,284,835
1860	21,440,185	19,015	60,344,630	4,606,815	53,383,640	1881	16,360,290	84,295	26,580,780	7,117,910	21,248,380
1861	21,212,205	49,360	32,173,180	5,533,135	25,958,410	1882	24,281,960	62,040	32,331,945	5,436,695	10,931,375
1862	25,952,160	30,035	48,807,725	3,375,445	35,351,760	1883	25,475,675	821,320	51,790,110	4,388,975	32,542,290
1863	34,407,845	167,050	68,136,990	5,386,215	46,257,485	1884	27,347,285	30,705	37,042,530	5,011,765	18,300,000
1864	4,462,707	135,530	70,185,835	6,202,250	57,398,425	1885	22,691,855	503,515	36,645,075	7,999,525	48,487,114
1865	49,375,160	175,340	57,441,600	7,047,610	52,429,325	1886	14,652,615	1,557,465	47,103,915	2,964,875	27,121,414
1866	31,864,470	3,242,090	100,922,035	7,578,670	72,535,245	1887	13,453,580	3,111,505	29,866,845	3,868,255	44,142,013
1867	22,907,360	4,047,695	43,277,160	8,461,800	30,544,285	1888	15,337,540	1,154,430	37,280,520	4,791,475	36,297,132
1868	23,879,620	832,285	34,997,250	7,027,445	21,566,425	1889	14,783,175	1,446,305	36,599,805	5,047,435	37,937,814
1869	20,884,880	88,120	49,894,890	6,889,780	21,035,155	1890	24,034,095	2,157,940	42,753,140	5,006,075	57,931,323
1870	28,452,000	491,415	41,322,035	4,720,350	37,367,800	1891	30,811,235	2,014,795	58,162,365	4,742,780	32,670,498
1871	13,912,870	2,502,265	13,311,245	8,601,560	8,590,985	1892	....	....	36,965,055	5,513,345	......

NOTE.—The figures for the years 1851–84 are taken from Soetbeer's *Edelmetall Produktion*, pounds sterling being converted into dollars at the rate £1 = $5. The imports and exports for the years 1885–91 are from the *Statistical Abstract relating to British India*, rupees being converted into pounds sterling at the average rate of exchange each year for the imports and exports of silver, and at the coining rate for the imports of gold, pounds sterling being subsequently converted into dollars at £1 = $5. The imports and exports of silver for 1892, converted into dollars in the same manner, are from the London *Statist*. The coinage for the years 1885–91 is from the *Production of Gold and Silver in the United States*, 1891, rupees being calculated at the coinage rate, $0.4737. The imports and exports for years 1851–92, and coinage 1851–84, are stated for fiscal years which ended April 30 until 1867, and since that time March 31. The coinage for the years 1885–91 is presumably stated for calendar years. The average rates of exchange for the past eight years are as follows: Fiscal year 1885, rupee = 1s. 7.308d.; 1886, 1s. 6.254d.; 1887, 1s. 5.441d.; 1888, 1s. 4.893d.; 1889, 1s. 4.379d.; 1890, 1s. 4.565d.; 1891, 1s. 6.089d.; 1892, 1s. 4.733d.

EXPORTS OF SILVER FROM LONDON TO INDIA, CHINA, AND THE STRAITS.
(Pixley & Abell's Statistics.)

Year.	India.	China.	Straits.	Total.
1881	$12,375,612	$3,898,860	$3,577,729	$19,852,201
1882	18,604,945	1,584,318	7,354,255	27,543,518
1883	18,040,140	4,212,574	11,189,631	33,442,345
1884	26,073,909	5,018,714	8,136,097	39,228,720
1885	30,913,667	3,160,315	3,108,146	37,182,128
1886	21,159,591	1,769,425	2,892,064	25,821,080
1887	19,798,328	1,427,179	2,766,946	23,992,453
1888	21,162,116	1,153,002	3,219,321	25,534,439
1889	28,392,786	2,731,861	8,181,141	39,305,788
1890	35,673,177	1,284,498	4,441,197	41,398,872
1891	22,313,770	1,209,925	22,099,660	34,573,525
1892	36,145,995	739,410	38,267,390	56,019,100

Canada.—Gold is mined in the Dominion of Canada in the Provinces of Nova Scotia, Quebec, and British Columbia, and in the Saskatchewan River and Yukon districts of the Northwest Territory. The gold of British Columbia is won from placers and lodes, and the decrease in yield during recent years is attributed to the gradual working out of the river diggings and the slow development of the quartz-mining industry; but this province has very important natural resources, and as the Kootenay and other promising districts are opened more fully, the production of gold and silver will probably increase. The past year has witnessed some very important developments in the Kootenay region, concerning which Mr. Robert C. Adams of Montreal writes as follows: "In a limestone belt traversing this district are found galena and copper ores carrying silver. The first property to be opened was the Silver King, on Toad Mountain, near Nelson, on which a tunnel has been driven for 900 ft., exposing very valuable ore bodies. Near Nelson is also the Poorman gold mine—a quartz ledge, in granite formation, carrying free gold. At Ainsworth several silver claims have been opened, and shafts have been sunk from 100 to 200 ft. On the opposite shore of Kootenay Lake, the Blue Bell mine has a ledge of galena ore, low grade in silver, and carrying considerable zinc. A smelter is being erected near by at Pilot Bay, under the management of Dr. Hendryx. During the season of 1892 great activity has prevailed in the Slocan district, between Kootenay Lake and Arrow Lake. Many claims are being developed, and 50 tons of galena ore had been shipped by the 1st of October from the Freddie Lee mine, which averaged 125 oz. silver per ton. Transportation facilities are now being supplied, and there will doubtless be a great development in the near future. One hundred miles west and near the boundary-line, in the Okanagon district, quartz ledges carrying free gold exist, and preparations are being made to work them, though the average yield is low."

The gold mines of Nova Scotia have maintained a small but regular output since the year of their discovery—1861. The gold of this province occurs in the area of Cambrian rocks forming the Atlantic slope of the peninsula of Nova Scotia and extending from Canso on the north to Yarmouth on the south. The inclosing rocks consist of compact quartzites and sandstones locally known as "whin," frequently feldspathic, but rarely calcareous, associated with argillaceous slates, in some instances magnesian or chloritic. The veins occur along the denuded crests of anticlinal folds of the strata, and carry free gold associated with varying amounts of sulphurets, arsenical pyrites, etc.

The output of the Nova Scotia mines in 1892, according to the latest figures, was 23,500 oz., or about the same as in the previous year. Small but rich veins have been worked at South Uniacke and in the Musquodoboit section. The Dufferin mine has continued steadily in operation. Some work has been done at Country Harbor, Sherbrookes, and Mooseland, and a less amount in Queens County. A strong English syndicate has purchased several properties at Waverley and Montague, and satisfactory returns have been made.

The production of the gold placers of Quebec, which occur in the Compton and Chaudière districts, is insignificant. The gold-mining industry in the Northwest Territory is but just begun.

PRODUCTION OF GOLD IN THE DOMINION OF CANADA.

Year.	British Columbia.		Nova Scotia.		Quebec.		Northwest Territory.		Total.	
	Ounces.	Value at $17.50 per Oz.	Ounces.	Value at $19.50 per Oz.	Ounces.	Value at $17.50 per Oz.	Ounces.	Value.	Ounces.	Value.
1858....	40,275	$705,000	....	....	....	....	....	....	40,275	$705,000
1859....	92,289	1,615,072	....	....	....	....	....	....	92,289	1,615,072
1860...	127,345	2,228,543	....	....	....	....	....	....	127,345	2,228,543
1861....	163,206	2,666,118	....	....	....	....	....	....	163,206	2,666,118
1862....	151,823	2,656,903	7,275	$141,871	....	....	....	....	159,098	2,798,774
1863 ...	223,632	3,913,563	13,972	272,448	....	....	....	....	247,604	4,186,011
1864 ...	213,477	3,735,850	20,018	390,349	....	....	....	....	233,495	4,126,199
1865....	199,497	3,491,205	25,454	496,357	....	....	....	....	224,951	3,986,562
1866 ...	152,120	2,662,106	25,205	491,491	....	....	....	....	177,325	3,153,597
1867....	141,763	2,480,868	27,311	532,563	....	....	....	....	169,074	3,013,431
1868....	135,598	2,372,972	20,541	400,555	....	....	....	....	156,139	2,773,325
1869 ...	101,427	1,774,978	17,868	348,427	....	....	....	....	119,295	2,123,405
1870 ...	76,397	1,336,956	19,866	387,392	....	....	....	....	96,263	1,724,348
1871....	102,825	1,799,440	19,229	374.972	....	....	....	....	122,054	2,174,412
1872....	92,055	1,610,972	13,095	255.349	....	....	....	....	105,150	1,866.321
1873....	74,614	1.305,749	11,852	231,122	....	....	....	....	86,466	1,536,871
1874 ...	105.406	1,844,618	9,141	178,244	....	....	....	....	114,547	2,022,862
1875 ...	141,423	2,474.904	11,212	218.629	....	....	....	....	152,635	2,693,533
1876 ...	102,094	1,786,648	11,979	233,585	....	....	....	....	114,073	2,020,233
1877...	91.891	1,608,182	16,882	329,205	689	$12,057	....	....	109,462	1,949.444
1878 ...	72,869	1,275,204	12,577	245,253	1,024	17,937	....	....	86,470	1,538,394
1879...	73,717	1,290,058	13,760	268,328	1,884	32,972	....	....	89,361	1,591,258
1880 ...	57,933	1,013,827	13,222	257.823	1,896	33,174	....	....	73,051	1,304,824
1881....	59,813	1,046,737	10.757	209,755	3,238	56,661	....	....	73,808	1,313,153
1882 ..	54,519	954.085	14,107	275,090	977	17,093	....	....	69,603	1,246,268
1883 ..	45.386	794,252	15,446	301.207	1,016	17,787	....	....	61,848	1,113,246
1884...	42,066	736,165	16.079	313.554	498	8,720	....	....	58,643	1,058,439
1885....	40,785	713,738	22,203	432,971	121	2,120	....	....	63,109	1,148,829
1886....	51,523	903,651	23,362	455,564	227	3,981	....	....	75,112	1,363,196
1887....	39,640	693,709	21,212	413,631	91	1,604	....	....	62,456	1,108.944
1888 ...	35,240	616,731	22,407	436,939	204	3,563	2,428	$41,200	60,279	1,098,433
1889....	53,192	588,923	26,155	510,029	60	1,207	11,471	195,000	90,878	1,295,159
1890...	29,084	494,436	24,358	474,990	75	1,350	10,259	179,000	63,776	1,149,776
1891....	....	....	....	....	....	....	....	....	51,040	925,486

Germany.—The Mansfield copper mines, the silver-lead mines at Mechernich in the Bonn district, and the mines of the Upper and Lower Harz are the principal sources of silver in Germany. Considerable quantities of argentiferous lead and copper ores are imported, however, from Bolivia, Mexico, Peru, Chile, and Australia, and the output of gold and silver by the metallurgical works of Germany is much more than that of the mines. It is necessary, therefore, in order to avoid counting the silver of foreign origin twice, to credit Germany only with the yield of its mines.

The only real silver lodes of Germany are those of Andreasberg in the Harz, which occur in schists of "thonschiefer" and "grauwacke" of Silurian age. There are several separate veins, but all are very thin. For the last two years there has been a considerable increase in the amount of ore mined on account of the more extensive employment of machine borers. The argentiferous galena ores of Germany generally carry small quantities of gold, the richest being those of Freiberg.

PRODUCTION OF GOLD AND SILVER IN GERMANY,* 1876–91.

[Product of smelting-works.]

Years.	Silver.		Gold.		Years.	Silver.		Gold.	
	Kilos.	Value.	Kilos.	Value.		Kilos.	Value.	Kilos.	Value.
1876..........	139,779	$5,312,314	281.3	$186.952	1884........	248,116	$9,263,965	556.0	$387,714
1877..........	147,612	5,588,545	307.9	204,630	1885..........	309,418	11,034,448	1,378.5	963,728
1878..........	167,660	6,347,583	378.5	264,084	1886..........	319,598	10,676,837	1,064.9	743,584
1879..........	177,507	6,629,531	466.7	325,599	1887..........	367,634	12,039,502	2,250.7	1,570,370
1880..........	186,010	7,151,890	463.0	322,938	1888..........	406,603	12,869,059	1,792.7	1,250,953
1881.........	186,990	7,128,520	380.6	265,641	1889..........	403,036	12,703,182	1,958.1	1,366,377
1882..........	214.982	8.190.764	376.1	262,789	1890..	402,945	14,037,716	1,855.0	1,290,417
1883..........	235.063	8,771.974	457.3	319.578	1891...... ...	444,852	14,749.420	3,077.0	2.141,998

* From *Berichten des Kaiserlichen Statistischen Amts zu Berlin.*

PRODUCTION OF SILVER IN GERMANY,* 1493–1876.

Period.	Number of Years.	Total Kilos.	Annual Average.		Period.	Number of Years.	Total Kilos.	Annual Average.	
			Kilos.	Value.				Kilos.	Value.
1493–1520...	28	308,000	11,000	$457,244	1761–1780...	20	362,000	18,100	$752,375
1521–1544...	24	360,000	15,000	623,515	1781–1800...	20	478,000	23,900	993,467
1545–1560..	16	310,400	19,400	806,413	1801–1810...	10	209,100	20,900	868,764
1561–1580...	20	300,000	15,000	623,515	1811–1820...	10	236,800	23,700	985,154
1581–1600...	20	286,000	14,300	594,418	1821–1830...	10	282,400	28,200	1,172,208
1601–1620...	20	208,000	10,400	432,304	1831–1840...	10	297,600	29,800	1,238,717
1621–1640...	20	120,000	6,000	249,570	1841–1850..	10	360,000	36,000	1,496,413
1641–1660...	20	130,000	6,500	270,190	1851–1855...	5	244,800	48,960	2,035,153
1661–1680...	20	140,000	7,000	290,974	1856–1860...	5	307,550	61,510	2,556,828
1681–1700...	20	228,000	11,400	473,872	1861–1865...	5	341,640	68,320	2,839,904
1701–1720...	20	306,700	15,300	635,985	1866–1870...	5	445,620	89,125	3,724,719
1721–1740...	20	504,000	25,200	1,047,505	1871–1875...	5	715,400	143,080	5,947,503
1741–1760..	20	422,900	21,100	877,078					
					Total....	383	7,904,910	....	....

* From Soetbeer's *Edel-Metall Produktion*, Gotha, 1879. Values are calculated at the United States coining rate, i.e., one kilogram = $41.56.

Japan.—The gold mines of Sado, the most important producers in Japan, are situated in the northwestern portion of the island of Sado, in the Sea of Japan, 50 miles north of Niigata. There is no official record of the output of the mines for the whole time during which they have been worked, but they are said to have turned out in 276 years 1,230,348 oz. of gold and 62,078,216 oz. of silver. From the first year of Meiji to March of 1889, a period of 21 years and 3 months, the total output was 51,494 oz. of gold and 1,500,106 oz. of silver. The total production of Japan in 1890 was 23,401 oz. of gold and 1,701,903 oz. of silver.

Mexico.—Next to the United States, Mexico is the largest producer of silver at the present time. Its mines are chiefly argentiferous, the ores carrying but a comparatively small percentage of gold. The principal silver-mining camps are Guanajuato, Pachuca and Real del Monte, Zacatecas, and Catorce, at all of which the undertakings are of ancient origin. At Guanajuato the great yield has been derived from the famous Veta Madre; at Zacatecas from the Veta Grande; and at Real del Monte from La Biscaina. Of these old mines Pachuca and Real del Monte maintain their production at a high figure, but Zacatecas and Guanajuato, though still important, are waning fast. Notwithstanding this the production of silver in Mexico is steadily increasing, as many new mines are being opened, and improved machinery and more scientific methods are being applied to some of the old mines, so that it is now possible to win the metal from ores that formerly were valueless. During the past ten years, moreover, Mexico has been the field of important railway development, which has given good transportation facilities to many of the most productive mines.

The foolish policy of the United States in imposing a heavy duty on Mexican lead ores entering this country for treatment has resulted in the establishment of a great silver-lead smelting industry at Monterey and San Luis Potosi. The most important discovery in Mexico in recent years was that of the great silver-lead mines of Sierra Mojada in 1879, which, curiously, was about the same time that the great silver-lead deposits of Leadville, Colo., were being opened. The Sierra Mojada ores, which are of oxidized character, and rich in lead and iron, were drawn upon extensively by the smelters of the United States to make up for the deficiency of lead ore of domestic production until they were practically

excluded by the unwise legislation of the United States, and then became the basis of the lead-smelting industry that has grown up in Mexico.

Two important events in Mexico during the past year were the completion of new railways to Durango and Oaxaca, which will certainly hasten the development of the tributary districts. The silver mines of Durango are virgin compared with those of some of the other States of Mexico, having been suffered to lie idle in many cases on account of the refractory nature of their ores, rendering them unsuited for the native patio process of silver extraction, and because of the inaccessibility of the Sierras, in which they are situated. Considerable capital has been sent into this region during the past year, and it may be expected that the silver mines of Durango will show soon a notable increase in yield.

In Oaxaca there are no silver mines of importance, but several promising gold belts are known to exist, and the development in that State will probably result in an increased production of the yellow metal.

The mining industry of Mexico at the present time stands in much the same position as that of the United States fifteen years ago, when the era of railway building and the establishment of a great metallurgical industry was just dawning. The natural difficulties in the southern republic, and the poverty of many of its great areas in everything but mines, will cause the development of its resources to proceed more slowly than was the case in the United States, but there is no doubt that eventually all the important mining districts will be given improved means of transportation, and the smelting works already established are bound to be maintained, even if the imports on lead ores levied by the United States are removed. We may, therefore, expect to see a steady increase in Mexico's production of silver and gold.

PRODUCTION OF GOLD AND SILVER IN MEXICO,* 1521–1875.

Periods.	Years.	Silver.			Gold.		
		Total, Kilos.	Value, Dollars.	Yearly Average, Kilos.	Total, Kilos.	Value, Dollars.	Yearly Average, Kilos.
1521–44	24	82,000	3,407,920	3,400	5,040	3,349.584	210
1545–60	16	240,000	9,974,400	15,000	2.560	1,701,376	160
1561–80	20	1,004,000	41.726,240	50,200	6,800	4,519,280	340
1581–1600	20	1,486,000	61,758,160	74,300	9,600	6,380,160	480
1601–20	20	1,624,000	67,493.440	81,200	8,440	5,609,224	420
1621–40	20	1,764,000	73,311,840	88,200	8,020	5,330,092	400
1641–60	20	1,904,000	79,130,240	95,200	7,420	4,931,332	370
1661–80	20	2,042,000	84,865,520	102,100	7,265	4,828,319	360
1681–1700	20	2,204,000	91,598,240	110,200	7,380	4,904,748	365
1701–20	20	3,276,000	136,150,560	163.800	10,470	6.958,362	520
1721–40	20	4,615,000	191,799,400	230,800	13,600	9,038,560	680
1741–60	20	6,020.000	250,191,200	301.000	16,380	10,886.148	820
1761–80	20	7,328,000	304.551,680	366,400	26,170	17.392,582	1,310
1781–1800	20	11,249.000	468,312,440	562.400	24,580	16.353,148	1,230
1801–10	10	5,538,000	230,159,280	553.800	17,630	11.716,898	1,765
1811–20	10	3,120,000	129,667,200	312,000	10,710	7,117,866	1,070
1821–30	10	2,648,400	110,067.504	264,800	9.760	6,486,496	975
1831–40	10	3,309,900	137,559,444	331.000	8,640	5,742,144	865
1841–50	10	4,203,100	174,680,836	420,300	19,940	13,252,124	,995
1851–55	5	2,330,500	96,855,580	466,100	10,050	6,679,230	2,010
1856–60	5	2,239,000	93,052,840	447,800	6,800	4,519,280	1,358
1861–65	5	2,365,000	98,289,400	473,000	8,740	5,800,604	1,719
1866–70	5	2,604,500	108,243,020	520,900	8,950	5,849,080	1,790
1871–75	5	3,009,000	125,054,040	601,800	10,095	6,709,137	2,020
Total	....	76,205,400	3,167,096,424	....	265,040	176,145,584	....

* From Soetbeer's *Edelmetall Produktion*, Gotha, 1879. Values are calculated at United States coining rate: one kilogram of gold = \$664.60; one kilogram of silver = \$41.56.

PRODUCTION OF GOLD AND SILVER IN MEXICO, 1872-1892.

Years Ending—	Silver.		Gold.	
	Kilos.	Value.	Kilos.	Value.
1872-73	515,910	$21,441,000	1,467	$975,000
1873-74	488,790	20,314,000	2,037	1,354,000
1874-75	514,040	21,314,000	1,591	1,057,000
1875-76	522,820	21,728,000	1,636	1,087,000
1876-77	570,000	23,689,000	1,466	974,000
1877-78	597,620	24,837,000	1,124	747,000
1878-79	604,550	25,125,000	1,326	881,000
1879-80	644,860	26,800,000	1,417	942,000
1880-81	703,420	29,234,000	1,521	1,013,000
1881-82	703,540	29,239,000	1,410	937,000
1882-83	711,480	29,569,000	1,436	956,000
1883-84	762,640	31,695,000	1,588	1,055,000
1884-85	799,480	33,226,000	1,375	914,000
1885-86	820,790	34,112,000	1,544	1,026,000
1886-87	832,540	34,600,000	1,577	1,047,000
1887-88	840,040	34,912,000	1,551	1,031,000
1888-89	979,460	40,706,000	1,565	1,040,000
1889-90	997,560	41,500,000	1,655	1,100,000
1890-91	1,034,699	43,000,000	1,730	1,150,000
1891-92	1,100,818	45,750,000	1,919	1,275,000

The figures in the above table for the years 1872–85 are from the report of the Director of the Mint on the *Production of Gold and Silver in the United States*, 1886, p. 74, which credits them as official to *La Crisis Monetaria*, Mexico, 1885. The figures from 1886–91 are from the *Production of Gold and Silver in the United States*, 1891, p. 277. Weights are calculated from values at the United States coining rate, i.e. one kilogram of gold = $664.60 ; one kilogram of silver = $41.56.

These figures do not agree very well, however, with those of the Director of the Mint, himself, who states the production of Mexico for the calendar years 1886–1891 as follows:

Year.	Silver.		Gold.		Year.	Silver.		Gold.	
	Kilos.	Value.	Kilos.	Value.		Kilos.	Value.	Kilos.	Value.
1886	794,033	$33,000,000	924	$614,000	1889	1,143,985	$47,544,000	1,053	$700,000
1887	904,000	37,570,000	1,240	824,000	1890	1,211,646	50,356,000	1,154	767,000
1888	995,500	41,373,000	1,465	974,000	1891	1,275,265	53,000,000	1,505	1,000,000

These figures are based upon the amount of metal coined and the amounts in ores and bullion registered for export, with an allowance (5%) for clandestine export. No account is taken of the quantity used in the arts, and the allowance for clandestine export is generally believed to be too low.

Russia.—The gold-bearing districts of Russia are (1) the Ural; (2) Siberia, Eastern and Western; (3) parts of European Russia, including Finland and the Caucasus. Of these Siberia is by far the most important, a comparatively small proportion of the total output of the empire coming from the Ural, while the yield of Finland and the Caucasus is insignificant.

The production of gold in the Ural began in 1745, when gold-bearing quartz was found on the Pishma, a branch of the Tobol, northeast of Ekaterinenburg. Up to 1810 the yield of these mines steadily increased, but then fell off until, in 1838, it was but trifling. The first placers were accidentally discovered in 1774, and from that time more attention, with greater success, was paid to gold-washing than to quartz-mining. From 1822 the yield of the placers has exceeded that of the mines, and has constantly increased.

The regular mining of precious metals in Siberia began at Nertshinsk in 1704, but the placers remained undiscovered until 1829. The following year other and richer fields were found, and from that time gold-washing has been regularly carried on in Siberia.

The mining districts of Western Siberia are the Altai Mountains, the Maryinsk

district, and the Akmolinsk, Sempalatinsk, and Semiretshinsk regions. The first two are the most important. The total amount of gold found in Western Siberia from 1829 to 1880 was 71,379 kilos.

The mines of Eastern Siberia are far richer than those of the west. They are situated in the Atshinsk, Minushinsk, Yenessei, Kansk, Nijni-Udinsk, Irkutsk, Wercho-Lensk, Werchnie-Udinsk, Bargusinsk, Nertshinsk, Priamursk, Olekminsk, and Amoor districts, and also along the coast. The total gold production of Eastern Siberia from 1832 to 1880 was 735,611 kilos, almost the whole having been won from the placers. The amount of gold produced has steadily increased, due to the greater number of placers worked and the more quantity of sand washed, for the percentage of gold contained in the gravel has decreased in all districts except that of Olekminsk.

From 1880 to 1885 the production of gold in the Russian Empire decreased, then remained almost stationary until 1890, when there was a notable increase, due mainly to the greater yield of the Lena, Yenessei, and Amoor districts. No official figures of the output in 1891 have yet been issued, but the amount of refined gold deposited in the mint at St. Petersburg was 36,348 kilos, and that represents approximately the production.

Up to this time the alluvial gravels have been the chief source of the Siberian gold, and the production has been maintained, in face of the exhaustion of the old placers and the less yield of the gravel still unworked, even by the discovery of new deposits. This has led to a gradual transfer of operations from west to east; and as the natural boundaries of the country must soon be reached, it would seem as if Russia's production of gold is now at or near its maximum, and before long will begin to wane. Another stage of the industry will be commenced when improved machinery and modern methods of development are introduced in the country, and more attention is devoted to the quartz lodes, which are known to exist in the vicinity of the placers that have been so productive in the past.

TOTAL PRODUCTION OF GOLD IN RUSSIA BY DISTRICTS FROM 1814 TO 1880.*

Period.	Total Yield.		Ural. Per Cent.	Western Siberia. Per Cent.	Eastern Siberia. Per Cent.	Finland. Per Cent.
	Pounds.†	Kilos.				
1814–1860......	1,296,486	530,263	36.2	6.7	57.1	....
1861–1865......	264,614	108,227	21.3	4.6	74.1	....
1866–1870......	331,630	135,637	21.7	6.1	72.2	0.01
1871–1875......	387,300	158,406	17.2	7.2	75.5	0.10
1876–1880......	446,470	182,606	20.0	6.0	74.0	0.02
1814–1880......	2,726.500	1,115,139	27.6	6.4	66.0	0.01

* This table is from a report by the United States Consul-General at St. Petersburg, published in the *Production of Gold and Silver in the United States*, 1886, pp. 80–85.

† Russian pounds = $\frac{1}{40}$ pood = 0.409 kilogram.

PRODUCTION OF GOLD IN RUSSIA FROM 1881 TO 1890 BY DISTRICTS.
(From official reports.)

	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
	Poods.	Poods.	Poods.	Poods.	Poods.	Poods.	Poods.	Poods.	Poods.	Poods.
Government mines	107	99	101	91	61	103	95	86	106	114
East Siberia.	1,523	1,530	1,458	1,477	1,297	1,253	1,247	1,252	1,370	1,497⅛
West Siberia.	126	121	129	124	126	125	136	142	155	148½
Ural...	487	456	493	486	531	560	650	666	642	642½
Finland.	1¾	1	½	....	¾	⅓	⅓	¾	1½	1
Total......................	2,244¾	2,207	2,181½	2,178	2,015¾	2,041⅓	2,128⅓	2,146¾	2,274½	2,403⅛

PRODUCTION OF GOLD AND SILVER IN RUSSIA.*

Year.	Gold.		Silver.		Year.	Gold.		Silver.	
	Kilos.	Value.	Kilos.	Value.		Kilos.	Value.	Kilos.	Value.
1814......	263.3	....	....	....	1853.....	23,975.7	$15,933,730	16,769.0	$696,833
1815......	233.0	....	....	....	1854.....	26,154.8	17,382,746	17,276.8	718,145
1816......	258.4	....	....	....	1855.....	27,017.5	17,955,385	17,410.2	710,179
1817......	297.7	....	....	....	1856.....	27,118.0	18,022,882	16,980.4	705,821
1818......	272.7	....	....	....	1857.....	28,397.3	18,873,131	17,332.5	720,460
1819......	242.4	....	....	....	1858.....	28,021.0	18,622,738	16,826.4	699,455
1820......	325.1	....	....	....	1859.....	25,207.6	16,752,408	17,758.5	738,164
1821......	457.4	....	....	....	1860.....	24,428.4	16,236,380	17,533.6	748,922
1822......	880.9	$585,703	....	$758,523	1861.....	23,852.1	15,851,100	15,908.2	661,222
1823......	1,730.6	1,149,632	....	763,289	1862.....	23,927.4	15,903,159	16,929.1	703,778
1824......	3,371.2	2,240,477	....	772,821	1863.....	23,906.2	15,889,095	17,668.2	734,419
1825......	3,887.2	2,584,495	....	776,226	1864.....	22,898.8	15,218,476	17,888.6	743,543
1826......	3,771.7	2,517,542	....	775,545	1865.....	25,818.9	17,157,609	17,762.5	738,299
1827......	4,288.9	3,067,864	....	770,098	1866.....	27,183.5	18,066,429	18,222.0	757,433
1828......	4,780.3	3,166,932	....	755,799	1867.....	27,021.8	17,958,651	18,119.2	753,143
1829......	4,728.7	3,153,868	....	761,246	1868.....	28,034.1	18,631,447	18,310.0	761,110
1830......	6,268.1	4,165,240	21,001.0	872,914	1869.....	33,232.9	22,086,876	12,589.9	524,340
1831......	6,587.1	4,376,550	21,591.1	897,426	1870.....	35,426.3	23,544,601	14,210.3	590,681
1832......	6,925.0	4,601,795	21,482.6	892,660	1871.....	39,328.7	26,137,806	13,576.0	564,330
1833......	6,712.0	4,462,446	20,578.8	855,210	1872.....	36,179.5	25,129,700	12,321.6	512,173
1834......	6,635.0	4,409,210	20,654.8	859,296	1873.....	33,170.3	22,044,418	9,935.4	412,966
1835......	6,436.4	4,277,373	19,860.9	825,251	1874.....	33,221.9	22,079,255	11,799.9	490,520
1836......	6,652.2	4,421,077	19,671.7	817,080	1875.....	32,691.6	21,727,072	9,846.5	409,289
1837......	7,249.3	4,817,351	19,711.0	819,123	1876.....	33,631.0	22,362,309	11,195.0	465,327
1838......	7,258.8	5,368,217		835,464	1877.....	41,200.9	27,240,081	11,162.3	463,965
1839......	8,121.6	5,397,611		827,294	1878.....	42,133.0	28,000,624	11,452.6	476,221
1840......	7,502.1	4,986,095	20,959.2	820,485	1879.....	43,109.7	28,654,449	11,422.3	474,792
1841......	10,588.5	7,037,143		819,123	1880.....	43,273.1	28,759,860	10,102.0	419,911
1842......	14,891.4	9,897,072		821,846	1881.....	36,762.6	24,431,048	9,435.3	392,198
1843......	20,335.5	13,514,712		806,186	1882.....	36,152.4	23,867,935	8,022.1	323,427
1844......	20,966.2	13,933,849	19,548.2	812,314	1883.....	35,734.7	19,552,532	7,376.7	300,900
1845......	21,413.0	14,231,055	31,316.8	810,952	1884.....	35,677.4	21,874,129	9,662.6	388,724
1846......	26,400.1	17,544,957	19,562.8	812,995	1885.....	33,019.6	25,338,218	11,259.7	646,424
1847......	28,784.3	19,130,057	18,738.9	778,269	1886.....	33,439.3	20,518,000	13,272.5	528,100
1848......	27,596.7	18,340,772	18,610.3	773,502	1887.....	34,864.5	20,092,000	15,379.3	562,000
1849......	26,031.1	17,278,234	18,315.4	781,673	1888.....	35,165.5	21,302,000	15,135.8	604,000
1850......	23,814.4	15,827,041	17,499.6	727,201	1889.....	37,258.1	23,905,600	13,858.1	598,000
1851......	24,142.5	16,044,774	17,239.1	716,579	1890.....	39,371.2	25,484,000	14,562.5	568,000
1852......	22,388.5	14,878,812	17,414.5	723,865	1891.....	†36,348.0	24,131,500	13,432.2	575,500

* This table gives the production of unrefined gold and silver in Russia from 1814 to 1891 in kilograms. The weight product from 1814 to 1863, both years inclusive, is from official returns as given in the *Report of the United States Silver Commission*, 1877, Volume I, pp. 571-573; for the years 1863-90 the figures are taken from the Russian Statistical Year Book. Poods have been converted into kilograms at the rate: one pood = 16.3808 kilos. The values of the annual products of gold and silver in Russia given in the above table from 1822 to 1882, both years inclusive, are from the *Production of Gold and Silver in the United States*, 1886, p. 75; from 1882 to 1891 from subsequent reports of the Director of the Mint.

† Fine gold and silver.

South Africa.—Gold was discovered in the De Kaap district in 1884, and in 1885 the first "banket" vein of Witwatersrand was uncovered. These were the first important discoveries in the Transvaal, though isolated finds during ten years or more previous had indicated the probable existence of rich gold-fields in that region. Active mining operations were commenced at Witwatersrand in 1886, and the rapid development of its lodes since that time has formed one of the most phenomenal records in the history of the gold-mining industry.

The geological formation in the Witwatersrand gold-field consists chiefly of sandstones, shales, quartzites, and cherts, tilted into nearly a vertical position by the intrusion of a mass of granite to the north. Between the strata of sandstone, etc., are beds of conglomerate, which vary in coarseness and color, and which are in many instances auriferous. These conglomerate beds are named "banket," from their resemblance to a Boer cake of that name, but are also spoken of, although incorrectly, as "reefs," for they are regular beds interstratified with the sandstones.

The most important of the beds yet worked consist of strata in a width of about 200 ft., separated from each other by quartzite, and all more or less aurif-

erous. In the main reef series is the South Reef, in width from 6 in. to 3 ft., and very rich in some localities; the Middle Reef rich in some places, and in other places wanting; the Main Reef Leader, also rich, from 6 in. to 2 ft. in width; the Main Reef, from 4 ft. to 20 ft. in width, which is the principal source of the Witwatersrand yield; and the North Reef, which is small, but has shown good results in some places. The line of oxidation in these reefs varies from 1 ft. to 200 ft. below the surface. Above this line the rock is of reddish color; below it the rock is bluish.

In 1890 the total crushings at Witwatersrand amounted to 702,828 tons, which yielded 494,817 oz. of gold, or an average of 13.36 dwts. per ton. The total value of the yield was £1,735,491, or £2 6s. 8d. per ton. In 1891 there were milled 1,154,145 tons of ore, yielding 729,238 oz., or an average of 11.23 dwts. per ton. The total value of the product was £2,556,328, or £2 0s. 6d. per ton. For 1892 figures of production only have been compiled; these show a grand total of 1,210,865 ozs.

Predictions are already made in Johannesburg that in 1894 the district will be turning out 200,000 oz. of gold per month, but such an increase is hardly to be expected. Nevertheless, there seems little doubt that these reefs will continue to increase their output for some time yet. The occurrence of the gold of the Witwatersrand is unique. The lodes are auriferous sedimentary beds, existing in a formation whose continuity has been traced for many miles in length. It seems probable, therefore, that the gold-bearing strata will be found to have an important extent downward also.

The increase in the Witwatersrand product has been made in the face of a steady decrease in the yield of the rock crushed, following the exhaustion of the free-milling ore above the water-level. This has been due, of course, to the enlargement of the milling capacity, and to improved methods of mining and milling, introduced in great part by American engineers. The treatment of the pyrites concentrates seems to have been partially solved by the application of the cyanide and chlorination processes.

Mr. A. R. Goldring of Johannesburg, South Africa, contributes the following:

"Prior to September, 1888, the returns of the Witwatersrand were not kept with accuracy, but since that time the Witwatersrand Chamber of Mines has carefully collected and compiled the returns of gold production in the district. The amount stated for 1887 is an estimate of the production for that year and the preceding one, and to the returns for 1888 and 1889 received from companies 10,000 oz. have been added to cover gold sold to the banks of which the Chamber of Mines was not advised. From 1890 the monthly publications of the Chamber of Mines have shown the total production of the district.

"Many of the companies give the value of their gold, but where this is not done it is estimated by the Chamber of Mines at 70s. ($17.50) per oz. The average value of the gold produced is, however, nearer 72s. 6d. ($18.12) per oz.

"The average number of stamps running during 1892 was 1887. The total amount of ore crushed was approximately 2,000,000 tons, and the average yield of gold was 10 dwts. per ton. From the figures of total production the average appears as 12 dwts. per ton, the difference being due to gold recovered from tailings and concentrates.

"The gold contents of the reef retain their value as the workings deepen, and in some cases increase in richness; but the ore becomes pyritic, and a less proportion is secured from amalgamation. During the past year the application of the cyanide process for the recovery of gold from tailings has been gradually extended, and when it is generally adopted so that the tailings obtained within the year are treated during the year, it will be found that the actual value per ton of Witwatersrand ore is higher than is shown by the statistical statements published at present.

"Formerly many companies returned a tonnage measurement of 2240 lbs. Gradually a movement toward uniformity has taken place, and in October all the companies adopted the 2000-lbs. ton-measurement. This would make it appear as though the yield per ton had in some cases actually diminished, whereas the apparent decrease is solely the result of the alteration in the tonnage measurement.

"The dividends paid by mining companies of the Witwatersrand district from January to Nov. 26, 1892, amounted to £644,612 ($3,223,060). This, however, must not be taken as the cash distribution of the year, as many of the companies declare dividends during December for the previous quarter and half year.

"Both with respect to extra tonnage treated and increased profits earned, the Rand gold mines have made a great stride forward during the past twelve months. A review of the year, however short, would be incomplete which did not take into account the considerable amount of developing work which is being carried on, and which in the course of a few months will enable a number of companies to become producers and dividend-earners.

"The returns from the other districts of the Transvaal are incomplete; but, roughly speaking, Lydenburg shows a slight improvement, and the Klein Litaba is represented by the Birthday Company, which with a 10-stamp battery has shown a high yield per ton. The Witwatersrand Chamber of Mines is endeavoring to obtain regular returns from all gold-mining companies in the Transvaal, so as to be in a position to publish a monthly statement of production, not only for the Rand district, but of the entire gold production of the country. Outside the South African Republic gold-mining is prosecuted on a small scale in Swazieland and Mashonaland, but particulars thereof are not readily accessible."

PRODUCTION OF GOLD IN SOUTH AFRICA.

(From Reports of the Witwatersrand Chamber of Mines.)

Year.	Witwatersrand.		De Kaap.		Lydenburg, Zoutpansberg.		Klerksdorp, Potchefstrom.		Total.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
1887....	43,155	$755,212	......	... ..	......	......	......	......	43,155	$755,212
1888 ...	218,121	3,317.118	......	......	. ....	......	......	......	218,121	3,817,118
1889....	381,557	6,677,248	35,420	$646,415	25,000	$456,250	3,000	$54,750	444.977	7,834,663
1890....	494,817	8,434,486	23,610	430,832	14,315	261,249	10,358	189,034	543,100	9,315.651
1891 ...	729.238	12,433,754	66,598	1,215,414	31,829	580,879	10,682	194,946	838,347	14,414.993
1892....	1,210,862	21,190,085	......	... ..	......	......	......	......	1,268,252	22,128,051
Total.	3,077,250	52,807,903	......	......	......	. ....	......	.	3,355,952	58.265.688

NOTE.—The value of the Witwatersrand gold is calculated at $17.50 per oz, except where it is expressly stated by the company reporting. The De Kaap, Lydenburg, Zoutpansberg, Klerksdorp. and Potchefstrom gold is estimated at $18.25 per oz. It is greatly to be regretted that all mines do not report product in weights of *fine* gold and silver.

South America.—Formerly the various countries of South America ranked among the largest producers of gold and silver, but within recent years they have fallen off much in importance, with the exception of Bolivia, which still produces a large amount of silver annually, its output being exceeded only by that of Mexico and the United States. The chief silver mines of Bolivia at the present time are those of Oruro, Huanchaca, Aullagas, and the famous old mines of Potosi, which are being reopened by an American company after a long period of idleness. Next to Bolivia, Peru produces more silver than any other country in South America, but its output at present is small in comparison with that during the bonanza years of Cerro de Pasco. The product of silver in Chile has fallen off considerably during the past few years. The principal mines of this country are those of Caracoles, in the desert province of Atacama, near the Bolivian frontier, but the copper mines of Copiapo yield a considerable amount annually. Colombia is the largest producer of gold, the production of Brazil and Venezuela having fallen to insignificant amounts in comparison with their output in former years. On the other hand, the placers of British and Dutch Guiana, which have been opened within recent years, are producing annually an increasing amount of gold, while the Argentine Republic and Uruguay have become small producers of both the precious metals.

PRODUCTION OF GOLD AND SILVER IN BOLIVIA.

Period.	Gold. 1 kilo = $664.60.				Silver. 1 kilo = $41.47.			
	Total for Period.		Yearly Average.		Total for Period.		Yearly Average.	
	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.
1545-1560	16,000	$10,633,600	1,000	$664,600	2,930,500	$121,527,835	183,200	$7,597,304
1561-1580	16,000	10,633,600	800	531,680	3,035,600	125,886,332	151,800	6,294,316
1581-1600	24,000	15.950,400	1,200	807,520	5,086,700	210,945,449	254,300	10,547,272
1601-1620	24,000	15,950,400	1,200	807.520	4,118,400	170,790,048	205,900	8,539,502
1621-1640	20,000	13,292,000	1,000	664,600	3,443,000	142,781,210	172,100	7,139,060
1641-1660	20,000	13.292,000	1,000	664,600	2,784,000	115,452,480	139.200	5,772,624
1661-1680	20,000	13,292,000	1,000	664,600	2.010,000	83,354,700	100,500	4,167,735
1681-1700	20,000	13,292,000	1,000	664,600	1,858,800	77,084,436	92,900	3,854,221
1701-1720	12,000	7,975,200	600	398,760	981,200	40,700,364	49,100	2,035,018
1721-1740	12,000	7,975,200	600	398,760	865,600	35,896,432	43,300	1,794,821
1741-1760	12,000	7,975.200	600	398,760	1,163,600	46,254,492	53,200	2,312,724
1761-1780	16,000	10,633,600	800	531,680	1,675,000	69,462,250	83,800	3,473,112
1781-1800	20,000	13,292,000	1,000	664,600	1,960.700	81,310.229	98,000	4,065,521
1801-1810	10,000	6,646,000	1,000	664,600	965,000	40,018,550	96,500	4,001,855
1811-1820	6,000	3,987,600	600	398,760	493,000	20,444,710	49,300	2,044,471
1821-1830	4,000	2,658,400	400	265,840	423,000	17,541,810	42,300	1,754,181
1831-1840	6,000	3,987,600	600	398,760	610,000	25,296,700	61,000	2,529,670
1841-1850	6,000	3,987,600	600	398,760	660,000	27,370,200	66,000	2,737,020
1851-1855	5,000	3,323,000	1,000	664,600	366,000	15,178,020	73,200	3,035,604
1856-1860	5,000	3,323,000	1,000	664.600	366,000	15,178,020	73,200	3,035,604
1861-1865	5,000	3,323,000	1,000	664,600	359,000	14,887,830	71,800	2,977,566
1866-1870	5,000	3,323,000	1,000	664,600	450.000	18,661,500	90,000	3,732,300
1871-1875	10,000	6,646,000	2,000	1,329,200	1,112,500	46,135,375	222,500	9,227,075
1876-1878	3,162	2,161,465	1,054	720,488	730,770	30,305,031	243,590	10,101,677
1879			109	72,345			264,677	11,000,000
1880			109	72,345			264,677	11,000,000
1881	554	361,725	109	72.345	1,560,001	65,000,000	264,677	11,000,000
1882			109	72,345			384,985	16,000,000
1883			109	72,345			384,985	16,000,000
1884			109	72,345			240,616	10,000,000
1885			109	72,345			240,616	10,000,000
1886	560	371,835	109	72,345	1,089,776	46,291,170	240,616	10,000,000
1887			143	95,000			137,468	5,713,170
1888			90	59,800			230,460	9,578,000
1889			90	59,800			263,506	10,951,300
1890	292	193,800	101	67,000	963,684	38,953,500	301,112	12,514,200
1891			101	67,000			372,666	15,488,000

NOTE.—From 1545 to 1875 the figures are those of Dr. Soetbeer; from 1878 to 1891, those of the Director of the United States Mint. The figures for 1876 to 1878 are estimated, taking as a basis the output of the preceding and following five years.

PRODUCTION OF GOLD IN BRAZIL.

Period.	Total for Period.		Yearly Average.		Period.	Total for Period.		Yearly Average.	
	Kilos. (1 kilo = $664.60.)	Value.	Kilos.	Value.		Kilos. (1 kilo = $664.60.)	Value.	Kilos.	Value.
1691–1700.	15,000	$9,969,000	1,500	$996,900	1876–78...	4,845	$3,219,987	1,615	$1,073,329
1701–1720.	55,000	36,553,000	2,750	1,827,650	1879			1,510	1,003,540
1721–1740.	177,000	117,634,200	8,850	5,881,710	1880			1,345	893'887
1741–1760.	292,000	194,063,200	14,600	9,203,160	1881	6,089	4,013,815	1,116	741,694
1761–1780.	207,000	137,572,200	10,350	6,878,610	1882			1,116	741,694
1781–1800.	109,000	72,441,400	5,450	3,622,070	1883			952	633,000
1801–1810.	37,500	24,922,400	3,750	2,492,240	1884			952	633,000
1811–1820.	17,600	11,696,960	1,760	1,169,696	1885			1,204	800,000
1821–1830.	22,000	14,621,200	2,200	1,462,120	1886	5,312	3,530,300	1,502	998,000
1831–1840.	30,000	19,938,000	3,000	1,993,800	1887			984	654,000
1841–1850.	24,000	15,949,000	2,400	1,594,900	1888			670	445,300
1851–1855.	11,000	7,310,600	2,200	1,462,120	1889			670	445.300
1856–1860.	10,600	7,044,760	2,120	1,408,952	1890	2,010	1,335,900	670	445,300
1861–1865.	12,000	7,975,200	2,400	1,594,900	1891			670	445,300
1866–1870.	8,750	5,815,250	1,750	1,163,050					
1871–1875.	8,600	5,715,560	1,720	1,143,112					

NOTE.—The figures given for the years 1691 to 1875 are those of Dr. Soetbeer; from 1878 to 1891 those of the Director of the United States Mint.

GOLD AND SILVER PRODUCTION IN CHILE, 1545–1875.

Period.	Gold. 1 Kilo = $664.60.			Silver. 1 Kilo = $41.47.		
	Total.	Annual Average.		Total.	Annual Average.	
	Kilos.	Kilos.	Value.	Kilos.	Kilos.	Value.
1545–1560	32,000	2,000	$1,329,200	....	....	....
1561–1580	8,000	400	265,840	....	....	....
1581–1600	8,000	400	265,840	....	....	....
1601–1620	7,000	350	232,610	....	....	....
1621–1640	7,000	350	232,610	....	....	....
1641–1660	7,000	350	232.610	....	....	....
1661–1680	7,000	350	232,610	....	....	....
1681–1700	7,000	350	232,610	....	....	....
1701–1720	8,000	400	265,840	....	....	....
1721–1740	8,000	400	265,840	20,000	1,000	$41,568
1741–1760	10,000	500	332,300	30,000	1,500	62,351
1761–1780	20,000	1,000	664,600	50,000	2,500	103,919
1781–1800	40,000	2,000	1,329.200	100,000	5,000	207,838
1801–1810	31,100	3.110	2,666,904	70,000	7,000	290,974
1811–1820	20,000	2,000	1,329,200	50,000	5,000	207,838
1821–1830	12,000	1,200	797,520	60,000	6,000	249,406
1831–1840	12,000	1,200	797,520	200,000	20,000	831,353
1841–1850	10,000	1,000	664,600	450,000	45,000	1,870,545
1851–1855	2,000	400	265,840	342,000	68,400	2,843,229
1856–1860	1,500	300	199,380	256,000	51,200	2,128,265
1861–1865	2,000	400	265,840	221,000	44,200	1,837,291
1866–1870	2,000	400	265,840	349,000	69,800	2,901,424
1871–1875	2,000	400	265.840	411,000	82,200	3,416,863
1876–1878	891	297	197,386	306,696	102,232	4,239,561
1879		194	128,869		122,275	5,081,747
1880		194	128,869		122,275	5,081,747
1881	1,327	194	128,869	654,931	122,275	5,081,747
1882		245	163,000		128,106	5,325,000
1883		500	332,000		160,000	6,650.000
1884		500	332,000		160,000	6,650,000
1885		500	332,000		210,000	8,727,600
1886	6,832	500	332,000	965,367	210,000	8,727,600
1887		2,379	1,581,400		199,516	8,291.920
1888		2,953	1,962,430		185,851	7,723,957
1889		2,162	1,436,600		123,696	5,140,800
1890	6,486	2,162	1,436,600	319,577	123,696	5,140,800
1891		2.162	1,436.600		72,185	3.000.000

NOTE.—From 1545 to 1875 the figures are those of Soetbeer; from 1878 to 1891, those of the Director of the United States Mint. The output of the three years 1876 to 1878 was estimated on the basis of the three preceding and three following years.

PRODUCTION OF GOLD IN COLOMBIA.

Year.	Total for the Period.		Yearly Average.		Year.	Total for the Period.		Yearly Average.	
	Kilos.	Value.	Kilos.	Value.		Kilos.	Value.	Kilos.	Value.
1537–1544.	16,000	$10,633,600	2,000	$1,329,200	1851–1855.	17,500	$11,630,500	3,500	$2,326,000
1545–1560.	32,000	21,267,200	2,000	1,329,200	1856–1860.	17,500	11,630,500	3,500	2,326,000
1561–1580.	40,000	26,584,000	2,000	1,329,200	1861–1865.	17,500	11,630,500	3,500	2,326,000
1581–1600.	40,000	26,584,000	2,000	1,329,000	1866–1870.	17,500	11,630,500	3,500	2,326,000
1601–1620.	60,000	39,876,000	3,000	1,993,800	1871–1875.	17,500	11,630,500	3,500	2,326,000
1621–1640.	60,000	39,876,000	3,000	1,993,800	1876–1880.	20,000	13,292,000	4,000	2,658,400
1641–1660.	70,000	46,522,000	3,000	1,993,800	1881....	....	....	4,814	3,200,000
1661–1680.	80,000	53,168,000	4,000	2,658,400	1882....	....	....	5,802	3,856,000
1681–1700.	80,000	53,168,000	4,000	2,658,400	1883....	....	....	5,802	3,856,000
1701–1720.	100,000	66,460,000	5,000	3,323,000	1884....	....	....	5,802	....
1721–1740.	100,000	66,460,000	5,000	3,323,000	1885....	....	....	3,762	2,500,000
1741–1760.	100,000	66,460,000	5,000	3,323,000	1886....	....	....	3,762	2,500,000
1761–1780.	80,000	53,168,000	4,000	2,658,400	1887....	....	....	4,514	3,000,000
1781–1800.	90,000	59,814,000	4,500	2,990,700	1888....	....	....	4,514	3,000,000
1801–1810.	50,000	33,230,000	5,000	3,323,000	1889....	....	....	5,161	3,429,000
1811–1820.	30,000	19,938,000	3,000	1,993,800	1890....	....	....	5,416	3,599,473
1821–1830	32,000	21,267,200	3,200	2,126,720	1891....	....	....	5,224	3,472,000
1831–1840.	33,000	21,939,800	3,300	2,193,180					
1841–1850.	34,000	22,596,400	3,400	2,259,640					

NOTE.—The figures given for the years 1537 to 1876 are from Soetbeer's *Edelmetall Produktion*, Gotha, 1879; those from 1876 to 1882 from Dr. Restrepo's *Gold and Silver Mines of Colombia.* From 1882 to 1891 the figures are those of the Director of the United States Mint.

PRODUCTION OF GOLD AND SILVER IN PERU.

Period.	Gold. 1 kilo = $664.60.				Silver. 1 kilo = $41.47.			
	Total for Period.		Yearly Average.		Total for Period.		Yearly Average.	
	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.
1533–1544	8,400	$5,582,640	700	$469,200	327,000	$13,560,690	27,300	$1,132,131
1545–1560	4,800	3,100,080	300	199,380	768,000	31,858,960	48,000	1,990.560
1560–1580	5,000	3,323.000	250	166,150	920,000	38,152,400	46,000	1,907,620
1580–1600	5,000	3,323.000	250	166,150	920,000	38,152,400	46,000	1,907,600
1601–1620	10,000	6,646,000	500	332,300	2,068,000	85,759,960	103,400	4,287,998
1621–1640	10.000	6,646,000	500	332.300	2,068,000	85,759,960	103,400	4,287.998
1641–1660	10,000	6,646,000	500	332,300	2,068,000	85,759,960	103.400	4,287.998
1661–1680	10.000	6,646,000	500	332,300	2,068,000	85,759,960	103,400	4,287,998
1681–1700	10.000	6,646,000	500	332,300	2,068,000	85,759,960	103,400	4,287.998
1701–1720	10.000	6,646,000	500	332,300	2,068,000	85,759,960	103,400	4,287,998
1721–1740	10,000	6,646,000	500	332,300	2,068,000	85,759,960	103,400	4,287,998
1741–1760	10,000	6.646,000	500	332,300	2,068,000	85,759,960	103,400	4.287,998
1761–1780	12,000	7,975,200	600	398,760	2,432,000	100,855,040	121,600	5,042.752
1781–1800	13,000	8,639,800	650	431,990	2,568,000	106,494,960	128.400	5.324,748
1801–1810	7,800	5,183,880	780	518,388	1,513,000	62,744,110	151,300	6.274,411
1811–1820	4,500	2,990,700	450	299,070	880,000	36.493,600	88,000	3,649,360
1821–1830	3,200	2,126,720	320	212,672	580,000	24,052,600	58,000	2,405,260
1831–1840	4.500	2,990,700	450	299,070	900,000	37,323,000	90,000	3,732,300
1841–1850	6,000	3,987,600	600	398,760	1,080,000	44,787,600	108,000	4,478,760
1851–1855	2,000	1,329,200	400	265,840	385,000	15,965,950	77,000	3.193.190
1856–1860	1,750	1,163,050	350	232,210	330,000	13,685,100	66.000	2,737,020
1861–1865	2,000	1,329,200	400	265,840	375,000	15,551,250	75,000	3,110,250
1866–1870	1,800	1,196,280	360	239,256	350,000	14,514,500	70.000	2,902,900
1871–1875	1,800	1,196,280	360	239,256	350,000	14,514,500	70,000	2,902,900
1876–1880	1,350	897,210	270	179,442	289,770	12,016,760	57,954	2,403,352
1881			180	120,000			45,909	1,908,000
1882			180	120.000			45,909	1,908.000
1883 (1881–1885)	946	630,000	180	120.000	231,476	9,620,000	45,909	1.908.000
1884			180	120.000			45.909	1.908.000
1885			226	150,000			47,840	1,988,000
1886			170	113,000			96,246	4,000.000
1887			158	105.000			75,263	3,128,000
1888 (1886–1890)	730	485,000	158	105,000	381,138	14,840,500	75,263	3,128,000
1889			140	93,000			68,575	2,850,000
1890			104	69,000			65,791	2,734,500
1891	113	75,000	113	75,000	74,879	3,112,000	74,879	3,112,000

NOTE.—From 1533 to 1875 the figures are those of Dr. Soetbeer; from 1880 to 1891, of the Director of the United States Mint. The figures for the period 1875 to 1880 are estimated on the basis of the preceding and following five years.

COINAGES OF NATIONS.*

	1887.		1888.		1889.		1890.		1891.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
United States	$23,972,383	$35,191,081	$31,380,808	$33,025,606	$21,413,931	$35,496,683	$20,467,182	$39,202,908	$29,222,005	$27,518,857
Mexico	398,647	26,844,031	300,480	26,658,964	319,907	25,294,726	284,859	24,081,192	280,565	24,493,071
Great Britain	9,728,498	4,142,136	9,893,375	3,681,886	36,502,536	10,827,602	37,375,479	8,352,232	32,720,633	5,141,594
Australia	24,122,267	...	24,415,230	...	29,325,529	...	25,702,600	...	26,389,044	...
India (*a*)	4,249	44,142,013	108,216	36,297,132	110,328	37,937,814	...	57,931,323	117,411	32,670,498
Canada	...	85,000	...	247,174	...	16,585	...	38,000	...	200,000
France	4,760,960	1,719,742	106,949	1,112,379	3,373,215	71	3,976,340	...	3,362,450	...
Cochin China	...	3,126,410	...	1,100,518	...	1,302,581	...	...	...	...
Monaco	...	...	...	...	...	...	...	...	386,000	...
Belgium	...	583,632	...	...	...	...	...	...	...	...
Italy	...	6,253,200	469,750	...	...	60,208	263,329	1,091	250,000	...
Switzerland	...	270,200	16,984	...	386,000	217,125	482,500	279,850	386,000	150,000
Spain	...	11,389,414	...	4,436,804	3,378,631	4,716,029	9,049,569	1,479,152	...	11,251,000
Portugal	270,000	960,120	102,600	1,533,600	96,120	680,400	407,160	540,000	169,560	7,277,040
Netherlands	163,831	76,380	143,051	...	823,943	132,660	...	198,990	...	295,000
Germany	28,135,270	715,343	34,340,722	989,127	48,166,245	177,079	23,835,512	...	14,277,220	1,139,252
Austria-Hungary (*b*)	2,669,750	5,556,395	2,747,633	5,516,190	3,294,987	4,528,259	2,818,750	3,857,118	2,885,561	3,035,799
Norway	...	80,400	...	53,600	...	53,600	...	120,600	...	55,000
Sweden	314,830	56,082	...	16,714	1,080,040	142,253	833,432	253,867	...	20,000
Denmark	...	...	...	62,483	...	27,607	547,931	...	...	123,628
Russia (*c*)	20,109,276	1,551,710	20,460,491	1,163,126	18,855,097	1,153,651	21,726,239	1,614,422	2,110,981	2,690,902
Turkey	...	...	66,000	74,448	...	...	44,840	...	3,266,000	221,000
Siam	...	2,216,065	...	...	...	1,446,626	...	...	...	...
Egypt	246,354	2,159,690	257,154	8,483	...	...	...	...	...	322,468
Japan	897,420	10,279,555	974,335	10,222,108	1,775,010	9,516,359	1,194,050	7,296,645	1,083,725	8,523,904
Haiti	...	500,000	...	...	...	...	...	300,000	...	...
Tunis	...	...	...	...	...	...	...	...	2,663,400	675,500
Chile	25,360	333,000	42,170	122,375	...	...	...	...	...	...
Argentina	9,173,370	...	8,316,325	...	...	...	...	...	...	...
Peru	...	1,685,000	...	3,258,000	...	2,842,531	...	2,687,119	...	...
Colombia	...	663,069	...	600,443	...	216,136	...	...	...	...
Venezuela	...	...	660,500	272,000	...	...	...	...	...	...
Brazil	...	...	26,082	883,555	...	...	86,093	821,996	...	...
Honduras	...	71,978	...	...	...	...	...	...	...	...
Congo	...	19,300	...	...	...	...	...	...	...	...
German East Africa	...	...	...	...	...	...	...	73,136	...	81,125
Great Comoro	...	...	...	...	...	...	...	1,978	...	...
French Colonies	...	...	...	...	...	...	...	6,436	...	...
Eritrea (Italian Colony)	...	...	...	...	...	...	...	567,814	...	650,000
British Africa	...	...	...	...	...	...	...	28,951	...	...
British West Indies	...	...	...	...	...	...	...	...	...	23,000
Nicaragua	...	400,000	...	...	...	...	...	...	...	...
Straits Settlements	...	177,000	...	244,000	...	300,000	...	...	...	336,000
Hawaiian Islands	...	...	...	...	...	...	...	...	...	...
Ecuador	...	...	...	473,177	...	...	...	...	...	...
Hongkong	...	400,000	...	1,105,000	...	1,100,000	...	430,000	...	1,500,000
Costa Rica	...	...	...	...	...	258,010	...	...	...	...
Bolivia	...	1,763,451	...	1,763,452	...	...	...	888,000	...	1,575,385

* From Director of the Mint's report.

(*a*) Rupee calculated at coining rate, $0.4737. (*b*) Silver florin calculated at coining rate, $0.482. (*c*) Silver ruble calculated at coining rate, $0.7718.

NOTE.—The following produced in 1891 only: Silver: China, $2,854,137; Morocco, $220,836; Zanzibar, $60,000; San Domingo, $183,350. Gold: South African Republic, $75,000.

The World's Production of Gold and Silver.

In order to appreciate the gold and silver production of the United States it is necessary to make comparison with that of the world, and to do this intelligently it is imperative to investigate the differing statistics of the world's production, and to reduce from all the data available the most probable figures. The following table is taken from Dr. Adolph Soetbeer's *Materials toward the Elucidation of the Economic Conditions affecting the Precious Metals,* and completed to 1892 from other reliable data:

WORLD'S PRODUCTION OF GOLD AND SILVER.

Period.	Mean Annual Product, Kilos.		Ratio of Silver to Gold, Weight.	Ratio of Gold to Silver, Value.	Period.	Mean Annual Product, Kilos.		Ratio of Silver to Gold, Weight.	Ratio of Gold to Silver, Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520...	5,800	47,000	8.1	(*a*)10.75	1856–1860..	201,750	904,990	4.5	15.29
1521–1544...	7,160	90,200	12.6	(*b*)11.25	1861–1865..	185,057	1,101,150	5.9	15 41
1545–1560...	8,510	311,600	36.6	(*c*)11.30	1866–1870..	195,026	1,339,085	6.9	15.56
1561–1580...	6,840	299,500	43.8	11.50	1871–1875..	173,904	1,969,425	11.3	15.98
1581–1600...	7,380	418,900	56.8	11.80	1876.....	165,956	2,323,779	14.0	17.88
1601–1620...	8,520	422,900	49.6	12.25	1877.....	179,445	2,388,612	13.3	17.22
1621–1640...	8,300	393,600	47.4	14.00	1878.....	185,847	2,551,364	13.7	17.94
1641–1660...	8,770	366,300	41.8	14.50	1879.....	167,307	2,507,5[illegible]7	15.0	18.40
1661–1680...	9,260	337,000	36.4	15.00	1880.....	163,515	2,479,998	15.2	18.05
1681–1700...	10,765	341,900	31.8	14.97	1881.....	158,864	2,592,639	16.3	18.16
1701–1720...	12,820	355,600	27.7	15.21	1882.....	148,475	2,769,065	18.6	18.19
1721–1740...	19,080	431,200	22.6	15.08	1883.....	144,727	2,746,123	19.0	18.64
1741–1760...	24,610	533,145	21.7	14.75	1884.....	153,193	2,788,727	18.2	18.57
1761–1780...	20,705	652,740	31.5	14.73	1885.....	159,289	2,993,805	18.8	19.41
1781–1800...	17,790	879,060	49.4	15.09	1886.....	159,741	2,902,471	18.2	20.78
1801–1810...	17,778	894,150	50.3	15.61	1887....	159,155	2,990,398	18.8	21.13
1811–1820...	11,445	540,770	47.2	15.51	1888.....	159,809	3,385,606	21.2	21.99
1821–1830...	14,216	460,560	32.4	15.80	1889.....	185,809	3,901,809	21.0	22.09
1831–1840...	20,289	596,450	29.4	15.75	1890.....	181,256	4,180,532	23.1	19.76
1841–1850...	54,759	780,415	14.3	15.83	1891.....	189,824	4,479,649	23.6	20.92
1851–1855...	199,388	886,115	4.4	15.41	**1892**.....	220,133	4,757,955	21.62	23.73

(*a*) For the period 1501–20; (*b*) 1521–40; (*c*) 1541–60.

Note.—The figures from 1493–1882, both years inclusive, are Soetbeer's; those for 1882–92 are from the reports of the Director of the Mint, except United States silver for 1892, which is from direct returns of U. S. refiners, etc.

The world's stock of gold and silver was exceedingly small when America was discovered, 1492. Chevalier estimates the stock in Europe at that time at only $193,000,000. It was greater in Asia, where some authorities conjecture that it may have been $1,500,000,000.*

Referring to the table, it is seen that between 1493 and 1660 the production of gold was nearly stationary. The value of the silver product increased about eight-fold between 1493 and 1600, owing to the fabulous yield of the mines of Potosi, in Bolivia, and Pachuca, Zacatecas, and Guanajuato, in Mexico, and the price of silver decreased from $65 per kilogram to $59. During the next 60 years the silver product decreased; but the price of silver, instead of increasing, decreased much more rapidly than in the earlier period.

From 1660 to 1780 the production of silver greatly increased; then rapidly decreased to 1820, and again greatly increased to 1860. The gold product increased from 1660 to 1760, decreased to 1820, and then increased more than tenfold between 1820 and 1860. The relative value of the total production of

* *Report of Silver Commission*, 1877, p. 8.

gold and silver varied through wide ranges from 1660 to 1860. Notwithstanding these violent fluctuations in both metals, and in the relative product of each, the price of silver per kilogram remained nearly stationary during these 200 years. From 1860 to 1885 the production of gold decreased and that of silver increased, but the great decline in price of silver did not set in until 1873. From a study of these statistics it becomes evident that so long as the production of silver as compared with that of gold fluctuated below the value ratio of the two metals, as established by their coinage values, the value of silver was practically unaffected.

The following table shows the world's production of gold and silver from 1849 to 1889 as given by different authorities. The figures in the columns headed "Soetbeer," from 1853 to 1885, inclusive, are from Dr. Adolph Soetbeer's *Materials toward the Elucidation of the Economic Conditions affecting the Precious Metals.**

VARIOUS ESTIMATES OF THE WORLD'S PRODUCTION OF GOLD AND SILVER.

Years.	Gold. (Millions of Dollars.)				Silver. (Millions of Dollars.)			
	Soetbeer.	Sir Hector Hay.	Mint Report, 1889.	Most Probable.	Soetbeer. (*a*).	Sir Hector Hay. (*c*)	Mint Report, 1889.	Most Probable. (*e*)
1849	....	....	27.1	....	....	....	39.0	....
1850	....	....	44.5	....	....	....	39.0	....
1851	....	....	67.6	....	....	....	40.0	....
1852	....	182.5	132.8	....	....	40.5	40.6	....
1853	(*b*)132.5	155.0	155.5	....	(*b*)36.8	40.5	40.6	....
1854	....	127.0	127.5	....	....	40.5	40.6	....
1855	....	135.0	135.1	(*b*)132.5	....	40.5	40.6	....
1856	....	149.5	147.6	134.0	....	41.0	40.7	....
1857	....	133.3	133.3	134.0	....	41.0	40.7	....
1858	(*b*)134.1	124.0	124.7	133.0	(*b*)37.7	41.0	40.7	....
1859	....	124.5	124.9	130.0	....	41.0	40.8	....
1860	....	119.0	119.3	127.0	....	41.5	40.8	(*d*)40.0
1861	....	114.0	113.8	122.0	....	43.0	44.7	45.0
1862	....	107.0	107.8	119.0	....	45.5	45.2	46.0
1863	(*b*)123.0	106.5	107.0	119.0	(*b*)45.8	49.5	49.2	49.0
1864	....	113.0	113.0	122.0	....	52.0	51.7	52.0
1865	....	120.0	120.2	126.0	....	52.5	52.0	52.0
1866	....	121.0	121.1	127.0	....	52.0	50.8	52.0
1867	....	116.0	104.0	127.0	....	50.5	54.2	54.0
1868	(*b*)129.6	120.0	109.7	126.0	(*b*)55.7	49.0	50.2	57.0
1869	....	121.0	106.2	125.0	....	49.0	47.5	61.0
1870	....	119.0	106.9	123.0	....	55.5	51.6	64.0
1871	....	116.5	107.0	119.0	....	59.0	61.1	68.0
1872	....	110.0	99.6	113.0	....	58.5	65.3	71.0
1873	(*b*)115.6	111.5	96.2	112.0	(*b*)81.9	64.0	81.8	75.0
1874	....	107.5	90.8	111.0	....	68.0	71.5	79.0
1875	....	110.5	97.5	111.0	....	69.0	80.5	82.0
1876	110.3	111.5	103.7	111.0	96.6	77.0	87.6	88.0
1877	119.3	117.0	114.0	116.0	99.3	87.0	81.0	93.0
1878	123.5	110.5	119.0	120.0	106.1	80.5	95.0	97.0
1879	119.2	104.0	109.0	114.0	104.2	79.0	96.0	99.0
1880	108.7	106.0	106.5	108.0	103.1	87.5	96.7	101.0
1881	105.6	103.0	103.0	104.0	107.8	94.0	102.0	106.0
1882	98.7	101.0	102.0	100.0	115.1	102.5	111.8	111.0
1883	96.1	98.0	95.4	97.0	120.4	103.0	115.3	115.0
1884	97.1	95.5	101.7	100.0	122.9	104.0	105.3	120.0
1885	102.7	97.5	108.4	106.0	132.0	106.5	118.5	125.0
1886	107.3	....	106.0	106.0	134.6	....	120.6	130.0
1887	106.3	....	105.8	106.0	141.9	....	124.3	136.0
1888	106.3	....	110.2	110.0	151.2	....	140.7	146.0
1889	....	....	121.0	120.0	....	....	158.8	159.0

(*a*) Figured from kilograms at United States coining value. (*b*) Average for five preceding years. (*c*) Subsequent to 1873 the figures in this column represent the product of silver calculated at its commercial value. (*d*) Average for preceding ten years. (*e*) Based on United States coining value, $1.2929 per oz.

Dr. Soetbeer's figures are in kilograms, and for the table have been reduced to United States coining values by multiplying by $664.61393 per kilogram for gold

* Second edition, Berlin, 1886, translated by Prof. F. W. Taussig, and published in Mr. Edward Atkinson's report of bi metallism in Europe, 1887. (Executive Document 34, Senate, Fiftieth Congress, first session.)

and by $41.56764 per kilogram for silver. The figures in the same column for 1885 to 1888, inclusive, are from Dr. Soetbeer's memoir on the production of gold and silver from 1885 to 1888, presented to the International Monetary Congress at Paris in 1889.

The figures attributed to Sir Hector Hay are from a table furnished by him to the British Commission on "Recent Changes in the Relative Values of the Precious Metals" (1887). His figures, being given in pounds sterling, have been multiplied by five to convert them (approximately) into dollars.

The figures up to 1874 in the columns headed "Mint report" are taken from a table published in the annual report of Hon. Horatio C. Burchard, Director of the United States Mint, on "Production of Gold and Silver in the United States" for 1880, p. 294. The original authority for this table is not given. The close agreement of these figures between 1853 and 1866 with those given by Sir Hector Hay would indicate that both were taken from the same original source for these years. The figures in this column subsequent to 1873 are from the annual report of Hon. Edward O. Leech, Director of the United States Mint, on "Production of Gold and Silver in the United States" for the year 1889, p. 61.

The following estimates of the gold and silver production of the world are taken from the reports of the Director of the United States Mint on the production of gold and silver in the United States. The figures for 1880 are from the report of 1882, those for 1881 from the report of 1884, those for 1882 from the report of 1885, those for 1883 from the report of 1887, those for 1884, 1885, and 1886 from the report of 1888, those for 1887, 1888, and 1889 from the report of 1890, and those for 1890 and 1891 from the report of 1891.

WORLD'S PRODUCTION OF GOLD AND SILVER FROM 1880 TO 1891.

(Kilogram of gold = $664.60. Kilogram of silver = $41.56, coining rate in United States silver dollars.)

Countries.	1880.				1881.			
	Gold.		Silver.		Gold.		Silver.	
	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.
United States	54,168	36,000,000	942,987	39,200,000	52,212	34,700,000	1,034,649	43,000,000
Australasia	43,282	28,765,000	5,465	227,125	*a*46,178	30,690,000	*b*3,970	164,983
Mexico	*c*1,488	989,160	*c*605,469	25,167,763	*d*1,292	858,909	*d*665,918	27,675,540
Russia	*c*42,960	28,551,028	*c*11,391	473,519	36,671	24,371,343	7,992	332,198
Germany	*e*350	232,610	*e*134,152	5,576,699	*f*350	232,610	*g*186,990	7,771,304
Austria-Hungary	1,647	1,094,596	48,000	1,994,880	1,867	1,240,808	31,359	1,303,280
Sweden	5	3,323	1,312	54,527	1	665	1,176	48,875
Norway	....	....	4,436	184,360	....	....	4,812	199,987
Italy	*h*109	72,375	*i*432	17,949	*j*109	72,375	*j*432	17,949
Spain	....	....	74,500	3,096,220	....	....	*k*74,500	3,096,220
Turkey	7	4,918	1,719	71,441	7	4,918	1,719	71,441
Canada	1,226	815,089	1,641	68,205	1,648	1,094,926	1,641	68,205
Argentina	*c*118	78,546	*c*10,109	420,225	*l*118	78,546	*l*10,109	420,225
Colombia	*c*6,019	4,000,000	*c*24,057	1,000,000	*l*6,019	4,000,000	*l*24,057	1,000,000
Bolivia	*m*109	72,345	*m*264,677	11,000,000	109	72,375	264,677	11,000,000
Chile	*m*194	128,869	*m*122,275	5,081,747	194	128,869	122,275	5,081,747
Brazil	1,345	893,887	....	....	1,116	741,694	....	....
Venezuela	3,423	2,274,692	....	....	*k*3,423	2,274,692	....	....
Japan	*c*702	466,548	*c*22,460	916,400	*l*702	466,548	*l*22,046	916,400
Africa	*c*3,000	1,993,800	....	....	*g*3,000	1,993,800	....	....
Total	160,152	106,436,786	2,275,082	94,551,060	155,016	103,023,078	2,458,322	102,168,354

(*a*) Official for Victoria and New South Wales, with estimated production of the other Provinces. (*b*) The mean of the official production for 1880 and 1882. (*c*) Estimated. (*d*) Coinage and export. (*e*) From total production 17% of gold and 25% of silver deducted for foreign ores. (*f*) Estimated. (*g*) Estimated by Dr. A. Soetbeer. (*h*) Estimated. (*i*) Dr. A. Soetbeer. (*j*, *k*, *l*, *m*) Estimated.

Countries.	1882.				1883.			
	Gold.		Silver.		Gold.		Silver.	
	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.
United States	48,902	32,500,000	1,126,083	46,800,000	45,140	30,000,000	1,111,646	46,200,000
Australasia	48,081	31,955,017	2,011	83,592	40,852	27,150,000	3,610	150,000
Mexico	1,409	936,223	703,508	29,237,798	1,438	956,000	711,480	29,569,000
Russia	35,913	23,867,935	7,781	323,427	30,272	20,119,000	9,990	415,000
Germany	376	249,890	214,982	8,934,652	458	304,000	*a*142,700	5,930,000
Austria-Hungary	*b*1,580	1,050,068	*b*47,118	1,958,224	1,638	1,088,000	48,700	2,024,000
Sweden	17	11,298	1,500	62,350	37	25,000	1,583	66,000
Norway	...	...	5,893	244,954	...	...	5,645	235,000
Italy	*c*109	72,375	*e*432	17,949	*d*142	94,000	*d*29,259	1,216,000
Spain	...	...	*e*74,500	3,096,220	...	...	*f*54,335	2,258,000
Turkey	10	6,646	2,164	89,916	*d*10	7,000	*d*1,323	55,000
France	...	...	14,291	594,053	...	...	6,356	264,000
Great Britain	...	...	...	...	2	1,000	8,500	353,000
Canada	*g*1,648	1,094,926	*g*1,641	68,205	1,435	954,000	*d*5,030	209,000
Argentina	*h*118	78,546	*h*10,109	420,225	118	78,000	11,500	478,000
Colombia	5,802	3,856,000	18,283	760,000	*i*5,802	3,856,000	*i*18,287	760,000
Bolivia	*g*109	72,375	*g*264,677	11,000,000	109	72,000	384,985	16,000,000
Chile	245	163,000	128,106	5,325,000	*j*500	332,000	*j*160,000	6,650,000
Brazil	*g*1,116	741,694	...	...	952	633,000	...	...
Venezuela	3,904	2,595,077	...	...	5,023	3,338,000	...	...
Peru	*k*179	119,250	*k*45,909	1,908,000	*j*180	120,000	*j*45,909	1,908,000
Japan	*l*952	632,520	*l*21,121	877,772	*i*290	193,000	*i*12,940	538,000
Africa	*m*3,000	1,993,800	...	...	*n*1,078	717,000	449	19,000
China	...	...	...	...	*o*8,057	5,355,000	...	...
Total	153,470	101,996,640	2,690,109	111,802,337	143,533	95,392,000	2,774,227	115,297,000

(*a*) The production officially reported with a deduction of 88,000 kilograms, given by Dr. Soetbeer for 1884 as the amount from foreign ores smelted. (*b*) Official for Hungary, with former annual production for Austria added. (*c, d, e*) Estimated. (*f*) Estimate of Dr. Soetbeer for 1883. (*g, h, i, j, k, l*) Estimated. (*m*) Estimated by Dr. A. Soetbeer, 1879. (*n*) From Board of Trade returns by A. Sauerbeck. (*o*) Dr. Ivan C. Michels.

Countries.	1884.				1885.			
	Gold.		Silver.		Gold.		Silver.	
	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.
United States	46,344	30,800,000	1,174,206	48,800,000	47,848	31,800,000	1,241,578	51,600,000
Australasia	42,558	28,284,000	4,525	188,000	41,287	*a*27,439,000	25,220	1,048,000
Mexico	1,780	1,183,000	655,870	27,258,000	1,304	867,000	772,670	32,112,000
Russia	32,913	21,874,000	9,360	389,000	38,125	25,338,000	15,550	646,000
Germany	555	369,000	27,598	1,147,000	1,378	916,000	24,567	1,021,000
Austria-Hungary	1,658	1,102,000	49,300	2,049,000	1,774	1,179,000	52,748	2,192,200
Sweden	20	13,000	1,816	75,500	47	31,000	2,326	96,000
Norway	...	...	6,387	265,500	...	...	7,200	299,000
Italy	*b*195	129,600	*b*33,839	1,406,350	*b*195	129,600	*b*33,839	1,406,350
Spain	...	...	*c*54,335	2,258,000	...	...	*c*54,335	2,258,000
Turkey	*b*10	7,000	*b*1,323	55,000	*b*10	7,000	*b*1,323	55,000
France	...	...	5,905	245,000	...	...	51,000	2,120,000
Great Britain	...	...	8,060	335,000	...	...	7,607	316,000
Canada	*d*1,435	954,000	*b*5,030	209,000	1,679	1,116,000	*b*5,030	209,000
Argentina	*d*118	78,000	*d*11,500	478,000	*d*118	78,000	*d*11,500	478,000
Colombia	*e*5,802	3,856,000	*e*18,287	760,000	*b*3,762	2,500,000	*b*9,625	400,000
Bolivia	*d*109	72,000	*f*240,616	10,000,000	*d*109	72,000	*f*240,616	10,000,000
Chile	500	332,000	160,000	6,650,000	*b*500	332,000	*b*210,000	8,727,600
Brazil	*d*952	633,000	...	...	1,204	800,000	2,640	110,000
Venezuela	*g*7,033	4,674,000	...	...	7,033	4,674,000	...	...
Peru	180	120,000	45,909	1,908,000	226	150,000	47,840	1,988,000
Central America	...	...	...	...	9	6,000	...	...
Japan	296	197,000	23,460	975,000	265	176,000	23,085	960,000
Africa	*g*1,250	830,000	*h*238	10,000	*h*2,083	1,384,000	*h*1,274	53,000
China	*h*9,362	6,222,000	...	...	*i*6,997	4,650,000	...	...
India (British)	...	...	...	...	203	135,000	...	...
Total	153,070	101,729,600	2,537,564	105,461,350	156,156	103,779,600	2,841,573	118,095,150

(*a*) G. W. Griffin, United States consul at Sydney, reports gold of Australasia, 1886, at $25,883,884, and 1885 at $27,361,603. (*b*) Estimated. (*c*) Estimate of Dr. Soetbeer for 1883. (*d, e*) Estimated. (*f*) Estimated upon annual average credited Bolivia by Dr. A. Soetbeer, and official statistics of exports and coinage for 1887. (*g*) Estimated. (*h*) Board of Trade returns by A. Sauerbeck. (*i*) Dr. Ivan C. Michels.

Countries.	1886.				1887.			
	Gold.		Silver.		Gold.		Silver.	
	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.
United States	52,663	35,000,000	1,227,141	51,000,000	49,654	33,000,000	1,283,855	53,357,000
Australasia	39,761	*a*26,425,000	29,403	1,222,000	41,119	27,327,600	6,422	266,900
Mexico	924	614,000	794,033	33,000,000	1,240	824,000	904,000	37,570,000
Russia	30,872	20,518,000	12,707	528,100	30,232	20,092,000	13,522	562,000
Germany	1,065	708,000	25,650	1,066,000	2,251	1,496,000	31,564	1,311,798
Austria-Hungary	*b*1,774	1,179,000	*b*52,748	2,192,200	1,877	1,247,450	53,391	2,218,900
Sweden	67	45,000	3,081	128,000	84	55,550	*c*5,828	242,250
Norway	....	....	*b*7,200	299,000	....	....	*d*5,147	214,000
Italy	195	129,600	33,839	1,406,350	*c*195	129,600	*c*33,839	1,406,350
Spain	....	....	*e*54,335	2,258,000	....	....	58,711	2,440,000
Turkey	10	7,000	1,323	55,000	*c*10	7,000	*c*1,323	55,000
France	....	....	46,789	1,944,550	....	....	54,314	2,257,300
Great Britain	....	....	10,124	420,750	2	1,000	9,964	414,100
Canada	2,002	1,330,442	5,030	209,000	1,773	1,178,637	10,868	451,680
Argentina	30	20,000	1,444	60,000	45	30,000	722	30,000
Colombia	3,762	2,500,000	9,625	400,000	4,514	3,000,000	24,061	1,000,000
Bolivia	*f*109	72,000	*g*240,616	10,000,000	143	95,000	137,468	5,713,170
Chile	500	332,000	210,000	8,727,600	2,379	1,581,400	199,516	8,291,920
Brazil	*h*1,502	998,000	*h*141	5,850	984	654,000	....	....
Venezuela	*i*5,020	3,336,000	....	....	2,960	1,967,216	....	....
Guiana (British)	....	....	....	....	370	245,902	....	....
Guiana (Dutch)	....	....	....	....	712	*j*473,000	....	....
Peru	*k*170	113,000	*k*96,246	4,000,000	*d*158	105,000	*l*75,263	3,128,000
Central America	*m*131	87,000	....	....	226	*n*150,000	48,123	*n*2,000,000
Japan	492	327,235	32,242	1,340,000	564	375,000	32,065	1,332,650
Africa	*o*2,163	1,438,000	3,165	132,000	2,888	1,919,600	432	17,960
China	*p*5,492	3,650,000	....	....	*p*14,294	9,500,000	....	....
India (British)	634	421,600	....	....	481	320,000	....	....
Total	149.338	99,250,877	2.896,882	120,394,400	159,155	105,774,955	2,990,398	124,280,978

(*a*) G. W. Griffin, United States consul at Sydney, reports the gold production of Australasia for 1886 at $25,883,884, and for 1885 at $27,361,603. (*b*, *c*, *d*) Estimated. (*e*) Estimate of Dr. Soetbeer for 1883. (*f*) Estimated. (*g*) Estimate based upon the annual average credited Bolivia by Dr. A. Soetbeer and official statistics of exports and coinage for 1887. (*h*) Exports of gold and silver through the custom-house at Rio de Janeiro. (*i*) Production of two mills of the El Callao Company. (*j*) *Jaarcijifers over* 1888 *en Vorige Jaaren*, No. 8, p. 115. (*k*, *l*, *m*, *n*) Estimated. (*o*) Board of Trade returns by A. Sauerbeck. (*p*) Imports of gold into Great Britain from China.

Countries.	1888.				1889.			
	Gold.		Silver.		Gold.		Silver.	
	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.
United States	49,917	33,175,000	1,424,326	59,195,000	49,353	32,800,000	1,555,486	64,646,000
Australasia	42,974	28,560,660	120,308	*a*5,000,000	49,784	33,086,700	144,369	*a*6,000,000
Mexico	1,465	974,000	995,500	41,373,000	1,053	700,000	1,335,828	55,517,000
Russia	32,052	21,302,000	14,523	604,000	34,867	23,173,000	14,389	598,000
Germany	1,792	1,190,963	32,051	1,332,022	1,958	1,301,286	32,040	1,331,576
Austria-Hungary	1,820	1,209,572	52,128	2,166,440	2,198	1,461,000	52,651	2,188,000
Sweden	76	50,000	4,648	193,000	74	48,900	4,267	177,400
Norway	....	....	5,147	214,000	....	....	5,147	214,000
Italy	148	98,000	35	1,454	*b*148	98,000	*b*35	1,454
Spain	....	....	51,502	2,140,400	....	....	*b*51,502	2,140,400
Turkey	*c*10	7,000	*c*1,323	55,000	10	7,000	*c*1,323	55,000
France	....	....	49,396	2,053,000	....	....	*b*49,396	2,053,000
Great Britain	220	146,000	9,047	376,000	97	64,370	9,522	395,734
Canada	1,673	1,111,959	9,264	385,000	1,919	1,275,045	*b*9,264	385,000
Argentina	47	31,000	10,226	425,000	*b*47	31,000	*b*10,226	425,000
Colombia	4,514	3,000,000	24,061	1,000,000	3,762	2,500,000	31,280	1,300,000
Bolivia	90	59,800	230,460	9,578,000	*b*90	59,800	*b*230,460	9,578,000
Chile	2,953	1,962,430	185,851	7,723,957	2,162	1,436,600	123,695	5,140,764
Brazil	670	445,300	....	....	670	*b*445,300	....	....
Venezuela	2,130	1,415,598	....	....	2,765	1,838,000	....	....
Guiana (British)	450	299,070	....	....	882	586,177	....	....
Guiana (Dutch)	487	*d*324,000	....	....	487	324,000	....	....
Peru	158	105,000	75,263	3,128,000	*f*140	93,044	68,575	2,850,000
Central America	226	*e*150,000	48,123	*e*2,000,000	226	*e*150,000	48,123	*e*2,000,000
Japan	*f*606	403,000	*f*42,424	1,763,140	*f*606	403,000	*f*42,424	1,763,140
Africa	6,771	4,500,000	....	....	12,920	8,586,632	....	....
China	*g*13,542	9,000,000	....	....	13,542	*b*9,000,000	....	....
India (British)	1,018	676,563	....	....	2,261	1,502,660	....	....
Total	165.809	110,196,915	3,385,606	140.706,413	182,021	120,971,514	3.820,002	158,759,468

(*a*, *b*, *c*) Estimated. (*d*) *Jaarcijifers over* 1888 *en Vorige Jaaren*, No. 8, p. 115. (*e*) Estimated. (*f*) Product of private mines in 1888; Government mines in 1889. (*g*) Imports of gold into Great Britain and British India from China.

Countries.	1890.				1891.			
	Gold.		Silver.		Gold.		Silver.	
	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.	Kilos.	Dollars.
United States	49,421	32,845,000	1,695,500	70,465,000	49,917	33,175,000	1,814,642	75,416,500
Australasia	44,851	29,808,000	258,212	10,731,300	47,245	31,399,000	311,100	12,929,300
Mexico	1,154	767,000	1,211,646	50,356,000	1,505	1,000,000	1,275,265	53,000,000
Russia	38,345	25,484,000	3,326	138,200	36,310	24,131,500	13,847	575,500
Germany	...	...	182,086	7,567,500	...	...	*a*180,000	7,480,800
Austria-Hungary	2,104	1,398,500	50,613	2,103,500	*e*2,104	1,398,500	*e*50,613	2,103,500
Sweden	88	58,500	4,180	173,700	*e*88	58,500	*e*4,180	173,700
Norway	...	...	5,539	230,200	...	...	*e*5,539	230,200
Italy	*i*150	100,000	*i*8,108	337,000	*i*150	100,000	*i*8,108	337,000
Spain	...	...	*c*51,502	2,140,400	...	...	*c*51,502	2,140,400
Turkey	*d*10	7,000	*d*1,323	55,000	*d*10	7,000	*d*1,323	55,000
France	200	133,000	71,117	2,955,600	*e*200	133,000	*e*71,117	2,955,600
Great Britain	4	3,000	9,075	377,200	4	*e*3,000	9,075	*e*377,200
Canada	2,506	1,666,000	12,464	518,000	2,506	*e*1,666,000	12,464	*e*518,000
Argentina	123	82,000	14,680	610,100	*e*123	82,000	14,680	*e*610,100
Colombia	5,416	3,600,000	19,971	830,000	5,224	3,472,000	31,232	1,298,000
Bolivia	101	67,000	301,112	12,514,200	*e*101	67,000	372,666	15,488,000
Chile	*b*2,162	1,436.600	*b*123,696	5,140,800	*b*2,162	1,436,600	72,185	*a*3,000,000
Brazil	670	*c*445,300	...	...	670	*c*445,300	...	...
Venezuela	2,512	1,670,000	...	...	1,504	1,000,000	...	...
Guiana (British)	1,693	1,125,000	...	...	*e*1,693	1,125,000	...	...
Guiana (Dutch)	668	444,200	...	...	668	*e*444,200	...	...
Guiana (French)	*f*825	548,000	...	...	*f*825	548,000	...	...
Peru	104	69,000	65,791	2,734,300	113	75,000	74,879	3,112,000
Uruguay	140	93,500	...	...	140	*e*93,500	...	...
Central America	226	*g*150,000	48,123	*g*2,000,000	226	*g*150,000	48,123	*g*2,000,000
Japan	764	507,700	42,468	1,765,000	775	515,000	43,282	1,798,800
Africa	14,877	9,887,000	...	...	21,366	14,199,600	...	...
China	*h*8,020	5.330,000	...	...	*e*8,020	5,330,000	...	...
India (British)	3,009	2,000,000	...	...	3,754	2,495,000	...	...
Corea	1,128	750,000	...	...	1,128	*e*750,000	...	...
Total	181,271	120,475,300	4,180,532	173,743,000	188,531	125,299,700	4,465,822	185,599,600

(*a, b, c, d, e, f, g*) Estimated. (*h*) Imports of gold bullion from China into London and India. (*i*) Estimated.

COMMERCIAL RATIO OF SILVER TO GOLD EACH YEAR SINCE 1687.

(From 1687 to 1832 the ratios are taken from Dr. A. Soetbeer; from 1833 to 1878 from Pixley and Abell's tables; and for subsequent years from daily cablegrams from London to the Bureau of the Mint.)

Year.	Ratio.	Year.	Ratio.	Year.	Ratio.	Year.	Ratio.	Year.	Ratio.	Year.	Ratio.
1687	14.94	1722	15.17	1757	14.87	1792	15.17	1827	15.74	1862	15.35
1688	14.94	1723	15.20	1758	14.85	1793	15.00	1828	15.78	1863	15.37
1689	15.02	1724	15.11	1759	14.15	1794	15.37	1829	15.78	1864	15.37
1690	15.02	1725	15.11	1760	14.14	1795	15.55	1830	15.82	1865	15.44
1691	14.98	1726	15.15	1761	14.54	1796	15.65	1831	15.72	1866	15.43
1692	14.92	1727	15.24	1762	15.27	1797	15.41	1832	15.73	1867	15.57
1693	14.83	1728	15.11	1763	14.99	1798	15 59	1833	15.93	1868	15.59
1694	14.87	1729	14.92	1764	14.70	1799	15.74	1834	15.73	1869	15.60
1695	15.02	1730	14.81	1765	14.83	1800	15.68	1835	15.80	1870	15.57
1696	15.00	1731	14.94	1766	14.80	1801	15.46	1836	15.72	1871	15.57
1697	15.20	1732	15.09	1767	14.85	1802	15.26	1837	15.83	1872	15.63
1698	15.07	1733	15.18	1768	14.80	1803	15.41	1838	15.85	1873	15.92
1699	14.94	1734	15.39	1769	14.72	1804	15.41	1839	15.62	1874	16.17
1700	14.81	1735	15.41	1770	14.62	1805	15.79	1840	15.62	1875	16.59
1701	15.07	1736	15.18	1771	14.66	1806	15.52	1841	15.70	1876	17.88
1702	15.52	1737	15.02	1772	14.52	1807	15.43	1842	15.87	1877	17.22
1703	15.17	1738	14.91	1773	14.62	1808	16.08	1843	15.93	1878	17.94
1704	15.22	1739	14.91	1774	14.62	1809	15.96	1844	15.85	1879	18.40
1705	15.11	1740	14.94	1775	14.72	1810	15.77	1845	15.92	1880	18.05
1706	15.27	1741	14.92	1776	14.55	1811	15.53	1846	15.90	1881	18.16
1707	15.44	1742	14.85	1777	14.54	1812	16.11	1847	15.80	1882	18.19
1708	15.41	1743	14.85	1778	14.68	1813	16.25	1848	15.85	1883	18 64
1709	15.31	1744	14.87	1779	14.80	1814	15.04	1849	15.78	1884	18.57
1710	15.22	1745	14.98	1780	14.72	1815	15.26	1850	15.70	1885	19.41
1711	15.29	1746	15.13	1781	14.78	1816	15.28	1851	15.46	1886	20.78
1712	15.31	1747	15.26	1782	14.42	1817	15.11	1852	15.59	1887	21.13
1713	15.24	1748	15.11	1783	14.48	1818	15.35	1853	15.33	1888	21.99
1714	15.13	1749	14.80	1784	14.70	1819	15.33	1854	15.33	1889	22.10
1715	15.11	1750	14.55	1785	14.92	1820	15.62	1855	15.38	1890	19.76
1716	15.09	1751	14.39	1786	14.96	1821	15.95	1856	15.38	1891	20.92
1717	15.13	1752	14.54	1787	14.92	1822	15.80	1857	15.27	1892	23.73
1718	15.11	1753	14.54	1788	14.65	1823	15.84	1858	15.38		
1719	15.09	1754	14.48	1789	14.75	1824	15.82	1859	15.19		
1720	15.04	1755	14.68	1790	15.04	1825	15.70	1860	15.29		
1721	15.05	1756	14.94	1791	15.05	1826	15.76	1861	15.50		

General Statistics.

The total coinage of silver dollars under Act of Feb. 28, 1878, was $378,166,793; under Act of July 14, 1890, $34,631,720; under Act of March 3, 1891, trade-dollar bullion, $5,078,472; grand total to Dec. 31, 1892, $417,876,985. The purchases of fine silver by the United States sinceFeb. 12, 1873, were as follows:

Act February 12, 1873	5,434,282 ounces.	Cost, $ 7,152,564	Average price, $1.314
" January 14, 1875	31,603,906 "	" 37,571,148	" " 1.189
" February 28, 1878	291,202,019 "	" 308,199,262	" " 1.058
" July 11, 1890, to December 1, 1892	129,779,322 "	" 124,652,429	" " 0.96
Totals	458,109,529	$477,575,403	$1.0425

The amount of gold used in the industrial arts in the United States in 1892 was, according to the Director of the Mint, $19,329,000, of which $10,588,703 was new bullion. The amount of silver used was $9,350,000 (coining value), of which $7,204,210 (coining value) represented new bullion. The total metallic stock on January 1, 1893, was estimated as: Gold, $649,788,020; silver, $593,365,365; total, $1,243,153,385. The stock of gold in the United States fell off during the year 1892 $39,000,000, while the stock of silver increased $46,000,000. The amount of money in circulation (exclusive of the amount in the Treasury) was $1,611,321,753 on January 1, 1893, an increase of $18,928,124 during the year.

HIGHEST, LOWEST, AND AVERAGE PRICE OF SILVER IN NEW YORK AND LONDON IN 1892.*

Month.	Highest.	Lowest.	Average Price per Ounce, British Standard, .925.	Equivalent Value of a Fine Ounce with Exchange at Par, $4.8665.	Average Monthly Price at New York of Exchange on London.	Eq'vt of Fine oz. based on Monthly Price and Average Rate of Exchange.	Average Monthly New York Price of Fine Bar Silver.
	Pence.	Pence.	Pence.				
January	43¾	41¼	42.830	$0.93888	$4.8525	$0.93515	$0.93494
February	41 13/16	41⅛	41.460	.90885	4.8754	.91106	.91198
March	41⅝	39	40.087	.87875	4.8775	.89699	.89907
April	40⅛	39¼	39.703	.86583	4.8417	.87229	.87379
May	40⅜	39 11/16	40.060	.87816	4.8788	.88029	.88120
June	41⅛	40 1/16	40.564	.88921	4.8839	.89298	.89430
July	40 3/16	39 1/16	39.632	.86877	4.8833	.87181	.87270
August	39 1/16	37⅞	38.295	.83947	4.8812	.84203	.84463
September	38 5/16	38⅛	38.158	.83646	4.8751	.83801	.84010
October	39⅝	38⅛	38.937	.85354	4.8623	.85287	.85740
November	39¼	38¾	38.971	.85428	4.8703	.85512	.85614
December	39⅜	37 15/16	38.346	.84058	4.8793	.84274	.84000
Average	....	....	39.753	.87106	4.8717	.87427	.87552

* Compiled by the Director of the Mint.

HIGHEST, LOWEST, AND AVERAGE PRICE OF BAR-SILVER IN LONDON.

[Per ounce British standard (0.925), since 1833, and the equivalent in United States gold coin of an ounce 1000 fine, taken at the average price.]

Years.	Lowest.	Highest.	Average.	Average.	Years.	Lowest.	Highest.	Average.	Average.
	Pence.	Pence.	Pence.			Pence.	Pence.	Pence.	
1833	58.750	59.875	59.188	$1.297	1863	61.000	61.750	61.375	$1.345
1834	59.750	60.750	59.938	1.313	1864	60.625	62.500	61.375	1.345
1835	59.250	60.000	59.688	1.308	1865	60.500	61.625	61.063	1.338
1836	59.625	60.375	60.000	1.315	1866	60.375	62.250	61.125	1.339
1837	59.000	60.375	59.563	1.305	1867	60.375	61.250	60.563	1.328
1838	59.500	60.125	59.500	1.304	1868	60.125	61.125	60.500	1.326
1839	60.000	60.625	60.375	1.323	1869	60.000	61.000	60.438	1.325
1840	60.125	60.750	60.375	1.323	1870	60.250	60.750	60.563	1.328
1841	59.750	60.375	60.063	1.316	1871	60.188	61.000	60 500	1.326
1842	59.250	60.000	59.438	1.303	1872	59.250	61.125	60.313	1.322
1843	59.000	59.625	59.188	1.297	1873	57.875	59.938	59.250	1.298
1844	59.250	59.750	59.500	1.304	1874	57.250	59.500	58.313	1.278
1845	58.875	59.875	59.250	1.298	1875	55 500	57.625	56.875	1.246
1846	59.000	60.125	59.313	1.300	1876	46.750	58.500	52.750	1.156
1847	58.875	60.375	59.688	1.308	1877	53.250	58.250	54.813	1.201
1848	58.500	60.000	59.500	1.304	1878	49.500	55.250	52.563	1.152
1849	59.500	60.000	59.750	1.309	1879	48.875	53.750	51.250	1.123
1850	59.500	61.500	61.063	1.316	1880	51.625	52.875	52.250	1.145
1851	60.000	61.625	61.000	1.337	1881	50.875	52.875	51.938	1.138
1852	59.875	61.875	60.500	1.326	1882	50.000	52.375	51.813	1.136
1853	60.625	61.875	61.500	1.348	1883	50.000	51.188	50.625	1.110
1854	60.875	61.875	61.500	1.348	1884	49.500	51.375	50.750	1.113
1855	60.000	61.625	61.313	1.344	1885	46.875	50.000	48.563	1.065
1856	60.500	62.250	61.313	1.344	1886	42.000	47.000	45.375	0.995
1857	61.000	62.375	61.750	1.353	1887	43.250	47.125	44.625	0.978
1858	60.750	61.875	61.313	1.344	1888	41.625	44.563	42.875	0.940
1859	61.750	62.750	62.063	1.360	1889	42.000	44.375	42.688	0.936
1860	61.250	62.375	61.688	1.352	1890	43.625	54.625	47.750	1.046
1861	60.125	61.375	60.813	1.333	1891	43.500	48.750	45.063	0.988
1862	61.000	62.125	61.438	1 346	1892	37.875	43.750	39.813	0.876

SILVER MINING COMPANIES—PRODUCTION AND RECEIPTS.

Year.	Mined Tons.	Milled. Dry Tons.	Milled. Assay Value, Ozs. per Ton.	Milled. Per Cent Saved.	Milled. Ozs. per Ton Saved.	Milled. Total Ozs. Saved.	Milled. Price Rec'd per Oz. Cts.	Ore Sold. Dry Tons.	Ore Sold. Assay Value, Ozs. per Ton.	Ore Sold. Total Ozs.	Ore Sold. Total Lbs. Lead.	Ore Sold. Price Rec'd per tn. $	Ore Sold. Price Rec'd per Oz. Cts.	Grand Total Ozs. Produced.	Total Expenditures. $	Total Receipts. $	Dividends. $
ALICE GOLD AND SILVER MINING COMPANY, MONTANA.																	
May 15, '80 to Jan. 1, '84	e84,586	84,586	a	a	35	c2,920,149	111	none						2,920,149	2,824,464	f3,227,418	400,000
Jan. 1, '84 to Jan. 1, '85	33,201	33,201	a	a	29	958,814	109	"						958,814	818,990	1,045,632	150,000
Jan. 1, '85 to Jan. 1, '86	34,996	34,996	a	a	26	909,403	103	"						909,403	890,667	932,367	125,000
Jan. 1, '86 to Jan. 1, '87	39,740	39,740	a	a	22	866,986	99	"						866,986	796,105	861,259	75,000
Jan. 1, '87 to Sept. 30, '87	27,789	27,789	a	a	23	636,930	97	"						636,930	603,619	616,918	
Sept. 30, '87 to Jan. 1, '89	14,529	14,529	a	a	24	355,516	97	"						355,516	321,180	346,092	25,000
Jan. 1, '89 to Jan. 1, '90	32,174	32,174	a	a	17	562,600	96	"						562,600	537,753	536,819	25,000
Jan. 1, '90 to Jan. 1, '91	39,455	39,455	a	a	20	806,716	107	"						806,716	715,148	861,579	100,000
Jan. 1, '91 to Jan. 1, '92	39,530	39,530	a	a	18	704,483	102	"						704,483	686,370	758,285	75,000
ELKHORN MINING COMPANY, LIMITED, MONTANA.g																	
1890	f11,404	9,270	45.5	86.8	39.5	366,507	94	1,065	96.5	102,798	107,214	83.76	a	469,305	211,353	f344,736	191,764
1891	15,057	11,646	40.4	93.8	37.9	459,435	96	3,235	84.2	272,389	613,495	64.22	a	731,824	300,470	439,133	319,607
GRANITE MOUNTAIN MINING COMPANY, MONTANA.																	
Sept. 3, '81 to Dec. 1, '83	f1,541	l1,435	a	a	a	246,694	109							246,694	153,401	354,745	
Dec. 1, '83 to Aug. 1, '85	5,538	4,575	145.7	93.4	136.4	622,810	108							622,810	485,244	931,423	260,000
Aug. 1, '85 to Aug. 1, '86	9,024	8,388	177.0	95.2	165.1	1,384,600	100							1,384,600	317,207	1,334,687	940,000
Aug. 1, '86 to Aug. 1, '87	15,845	14,366	164.0	94.7	152.0	2,182,944	95	385.8	a	a		531		m2,555,600	770,411	2,189,465	1,400,000
Aug. 1, '87 to Aug. 1, '88	26,478	25,993	130.6	93.4	122.0	3,170,583	93	151.8	a	a		579		m3,270,000	803,418	3,023,499	2,200,000
Aug. 1, '88 to Aug. 1, '89	37,249	f35,711	106.2	90.0	95.2	3,399,746	92	67.7	65.8	44,536		567	86	3,444,282	1,338,631	3,203,602	1,900,000
Aug. 1, '89 to Aug. 1, '90	70,440	60,213	70.9	92.3	65.4	3,938,913	99	43.2	72.6	31,374		524	72	3,970,287	1,336,504	3,743,902	2,500,000
Aug. 1, '90 to Aug. 1, '91	85,472	68,849	50.6	90.1	45.6	3,138,426	101							3,138,426	1,474,908	3,447,534	1,900,000
Aug. 1, '91 to Aug. 1, '92	84,761	81,264	37.7	91.2	34.4	2,798,021	93							2,798,021	1,696,896	2,786,789	1,020,000
DALY MINING COMPANY, UTAH.																	
Dec. 1, '84, through 1886	e22,088	12,858	45.3	90	40.8	524,051	97	e7,704	90.	755,015			79	1,279,066	g808,002	1,106,590	
1887	22,441	19,600	41.8	90	37.6	737,220	96	3,018	98.	296,654			79	1,033,874	499,337	938,252	375,000
1888	25,624	22,907	42.7	90.7	38.7	855,573	93	2,617	95.9	250,923			79	1,136,496	474,686	1,017,752	487,500
1889	no repo	rt obtai	nable														450,000
1890	23,870	20,795	35.7	88.8	31.7	658,841	103	2,351	67.6	158,874			93	817,715	434,658	826,463	450,000
1891	29,690	24,214	39.1	91.6	35.8	866,689	95	5,734	70.8	405,992			82	1,272,681	859,480	1,056,233	450,000
ONTARIO MINING COMPANY, UTAH.																	
Jan. 1, '77 to Mar. 1, '80	f50,411	47,707	90.9	88	80.1	3,817,830	113	62	a	a			a	3,817,830	1,879,092		2,600,000
Mar. 1, '80 to Apr. 1, '81	13,491	13,832	132.4	86	114.3	1,586,224	112	a	a	a			a	1,586,224	1,113,916		675,000
Apr. 1, '81 to Dec. 1, '83	46,069	50,705	105.1	91	95.4	4,865,665	111							4,865,665	3,688,390		1,800,000
Dec. 1, '83 to Jan. 1, '85	26,478	22,921	84.9	97	82.6	1,851,893	107	1,663	129.9	215,911			85	2,067,804	1,159,256		975,000
1885	29,461	22,418	73.4	96	70.8	1,559,219	101	8,559	92.8	194,310			80	2,353,529	1,027,486		975,000
1886	30,079	20,479	54.3	94	51.0	1,043,905	96	9,572	89.2	854,131			74	1,898,036	935,236		900,000
1887	34,000	24,427	47.4	92	43.8	1,068,984	93	9,411	101.4	954,078			78	2,023,062	916,623		900,000
1888	36,560	28,250	44.2	87	38.3	1,082,562	89	7,381	119.4	880,952			78	1,963,514	978,295		900,000
1889	36,237	26,950	40.5	89	35.9	967,489	90	9,509	105.6	1,004,278			73	1,971,767	1,005,214		900,000
1890	37,800	24,450	45.0	92	41.6	1,016,845	100	12,057	68.3	823,296			81	1,840,141	1,045,379		900,000
1891	37,650	25,650	38.9	91	35.3	906,156	95	12,168	79.5	967,348			76	1,873,504	1,022,975		900,000

Silver Mining Company—Costs.

Year.	Mining Costs per Ton Mined. Mining.	Prospecting.	Improvements.	Sundries.	Total.	Hauling.	Milling Costs per Ton Milled. Milling.	Improvements.	Total.	Grand Total, Cost per Ton, Mined.	Cost per Oz. Obtained by Milling	Cost per Oz. Sold in Ore.	Av. Gr'd To'l, Cost per Oz. Produced.
ALICE GOLD AND SILVER MINING COMPANY, MONTANA.													
	$	$	$	$	$	$	$	$	$	$	Cts.	Cts.	Cts.
May 15, '80 to Jan. 1, '84	7.99	3.55	1.44	*d*6.42	19.40	......	12.38	1.61	13.99	33.39	97	...	97
Jan. 1, '84 to Jan. 1, '85	6.19	3.15	2.06	3.55	14.95	......	8.57	1.15	9.72	24.67	85	...	85
Jan. 1, '85 to Jan. 1, '86	6.69	2.78	2.30	3.78	15.55	......	8.53	1.37	9.90	25.45	98	....	98
Jan. 1, '86 to Jan. 1, '87	6.21	2.70	.95	2.31	12.17	......	7.05	.81	7.86	20.03	92	....	92
Jan. 1, '87 to Sept. 30, '87	6.41	2.95	.84	2.77	12.97	......	7.27	1.48	8.75	21.72	95	....	95
Sept. 30, '87 to Jan. 1, '89	5.98	1.57	.29	4.06	11.90	......	7.15	3.06	10.21	22.11	90	...	90
Jan. 1, '89 to Jan. 1, '90	5.22	1.08	.07	3.36	9.73	......	6.12	.86	6.98	16.71	96	....	96
Jan. 1, '90 to Jan. 1, '91	5.43	1.75	.29	2.87	10.34	......	6.32	1.47	7.79	18.13	88	....	88
Jan. 1, '91 to Jan. 1, '92	5.90	1.58	.58	2.30	10.36	......	6.34	.67	7.01	17.36	97	....	97
ELKHORN MINING COMPANY, LIMITED, MONTANA.*g*													
1890	5.20	3.38	1.21	*h*9.79	......	*h*8.	73	....	*h*8.73	20.45	47	*j*10	*k*45
1891	*i*	1.58	*i*	10.64	......	9.	23	....	9.23	20.20	52	13	41
GRANITE MOUNTAIN MINING COMPANY, MONTANA.													
Sept. 3, '81 to Dec. 1, '83	22.39	....	*a*	....	.....	......	*a*	*a*	28.20	*r*99.95	62	....	62
Dec. 1, '83 to Aug. 1, '85	4.72	5.58	1.22	....	.....	......	14 80	*s*24.64	39.44	87.82	78	....	78
Aug. 1, '85 to Aug. 1, '86	4.72	4.32	.45	....	.....	......	13.67	2.28	15.95	35.15	23	....	23
Aug. 1, '86 to Aug. 1, '87	6.06	3.98	*t*3.08	....	.....	......	13.48	*u*14.48	27.96	48.62	30	....	30
Aug. 1, '87 to Aug. 1, '88	6.49	2.29	.04	....	.....	.....	11.34	*v*1.62	12.96	30.91	25	....	25
Aug. 1, '88 to Aug. 1, '89	6.63	1.89	.41	....	......	*p*1.62	10.61	*v*9.67	20.28	35.94	39	....	39
Aug. 1, '89 to Aug. 1, '90	5.84	2.42	.08	....	......	*q*.22	10.10	.19	10.29	19.40	34	....	34
Aug. 1, '90 to Aug. 1, '91	5.74	1.48	.27	....	.....	*q*.25	10.00	*w*.60	10.90	17.26	47	....	47
Aug. 1, '91 to Aug. 1, '92	6.04	2.05	*n*1.52	....	.....	*q*.20	9.04	*w*.78	9.82	20.02	61	..	61
DALY MINING COMPANY, UTAH.													
Dec. 1, '84, through 1886	5.03	4.50	3.70	.78	14.01	.88	10.15	1.40	11.55	*j*36.58	65	15	63
1887	6.31	3.06	3.00	— .71	11.66	.87	7.94	.82	8.76	22.25	57	13	48
1888	5.50	2.86	1.26	1.70	11.32	.82	6.40	1.02	7.42	18.52	51	13	42
1889		....	....	....	......			....	......	....	...	...	...
1890	4.06	1.85	4.09	1.13	11.13	.83	6.38	.46	6.84	18 21	59	18	53
1891	6.52	1.65	*h'*11.15	*i'*3.55	22.87	.83	6.27	.62	6.89	28.95	35	33	68
ONTARIO MINING COMPANY, UTAH.													
Jan. 1, '77 to Mar. 1, '80	8.15	1.61	3.92	1.93	15.61	.58	11.67	5.12	17.11	*j'*31.28	42	*a*	49
Mar. 1, '80 to Apr. 1, '81	14.25	3.21	14.16	4.70	36.32	.70	18.24	2.09	20.33	82.61	50	*a*	70
Apr. 1, '81 to Dec. 1, '83	16.03	2.27	21.73	2.13	42.16	.70	13.76	2.64	16.40	80.06	62	...	71
Dec. 1, '83 to Jan. 1, '85	9.85	4.55	8.88	1.72	25.00	.59	9.97	4.83	14.80	43.78	50	19	56
1885	9.44	3.86	5.95	2.66	21.91	.56	8.04	4.05	12.09	34.85	50	24	44
1886	8.44	4.31	4.31	3.25	20.31	.63	8.05	4.25	12.30	31.10	65	23	49
1887	7.24	4.38	3.40	1.95	16.97	.59	6.60	2.77	9.37	26.96	62	17	45
1888	7.17	4.36	4.20	1.50	17.90	.54	8.61	1.19	9.80	26.76	71	15	50
1889	6.78	4.46	3.35	1.20	15.99	.56	7.84	1.08	8.92	27.74	71	15	51
1890	6.83	3.96	6.42	1.80	19.02	.55	7.73	1.35	9.08	27.66	69	28	56
1891	7.53	4.01	4.62	1.50	17.36	.56	7.92	1.01	8.93	27.17	76	22	55
SMALL HOPES MINING COMPANY, COLORADO.													
Jan. 18, '80 to Apr. 1, '86	*a*	*a*	....	*a*	*e'*	.....	....	....	......	....	...	*a*	*a*
Apr. 1, '86 to June 1, '87	7.80	3.78	1.38	.24	12.20	......	....	....	......	12.20	....	19	19
June 1, '87 to June 1, '88	7.71	3.75	....	.34	11.80	.....	....	....	......	11.80	....	29	29
June 1, '88 to June 1, '89	12.69	4.16	....	—.09*d'*	16.76	......	.....	....	......	16.76	....	50	50
June 1, '89 to June 1, '90	*a*	*b'*	....	*a*	*a*	......	.....	....	......	....	....	*a*	*a*
June 1, '90 to June 1, '91	*a'*	*a*	.35	*a*	5.46	......	.....	....	......	5.46	....	*b*38	*b*38
June 1, '91 to June 1, '92	*a*	*c'*	....	*a*	7.22	......	.....	....	......	7.22	....	48	48

SILVER MINING COMPANIES—PRODUCTIONS AND RECEIPTS.

Year.	Mined Tons.	Smelted.						Ore Sold.						Grand Total Oz. Prod'ced.	Total Expenditures. $	Total Receipts. $	Dividends. $
		Dry Tons.	Per Cent Lead Saved.	Ozs. Silver Saved.	Lead Saved. Lbs.	Silver Saved. Ozs.	Price Rec'd per Ton. Cents.	Dry Tons.	Assay Value Ozs. per Ton.	Total Ozs.	Total Lbs. Lead.	Price Rec'd per Ton. $	Price Rec'd per Oz. Cents.				
SMALL HOPES MINING COMPANY, COLORADO.																	
Jan. 18, '80, to Apr. 1, '86...	*a*	None	....	......	....	....	......	*a*	*a*	*a*	*a*	*a*	*a*	*a*	525,789	2,539,460	1,937,500
Apr. 1, '86, to June 1, '87...	*e*25,708	"	....	......	....	....	......	*e*25,708	60.8	1,561,963	116,687	44.62	73	1,561,963	313,814	1,147,136	825,000
June 1, '87, to June 1, '88...	*e*21,426	"	....	......	....	....	......	*e*21,426	40.2	860,945	51,923	25.69	64	860,945	252,849	550,509	350,000
June 1, '88, to June 1, '89...	*e*6,337	"	....	......	....	....	......	*e*6,337	33.4	211,411	8,844	20.42	61	211,411	106,227	129,396	25,000
June 1, '89, to June 1, '90...	*a*	"	....	......	....	....	......	*a*	*x*32.8	*a*	*a*	*a*	*a*	*a*	124,055	130,390	....
June 1, '90, to June 1, '91...	*fy*20,000	"	....	......	....	....	......	*f*20,000	*b*14.5	*b*290,700	*a*	7.55	52	290,700	109,251	151,018	25,000
June 1, '91, to June 1, '92...	*f*23,819	"	....	......	....	....	......	*f*23,819	15.1	359,667	*a*	8.18	54	359,667	171,903	194,836	....
HORN SILVER MINING COMPANY, UTAH.																	
Feb. 17, '79, to Jan. 1, '82...	*f*64,281	51,758	25.9	36.1	26,800,297	1,870,368	113	*f*5,035	......	....	....	30.48	......	....	2,880,043	3,667,708	500,000
1882........	47,233	48,551	30.0	36.7	29,135,597	1,751,213	114	1,116	......	....	....	29.46	......	....	1,832,545	3,680,004	1,200,000
1883........	No rep	ort o	btainab	le....	....	....	......	....	......	....	....	......	......	....	....	....	....
1884–1886........	No rep	ort o	btainab	le...	....	....	......	....	......	....	....	......	......	....	1,886,097	3,134,912	1,200,000
1887........	3,317	......	....	......	....	....	......	3,461	......	....	....	26.64	......	....	*k'*209,392	131,330	....
1888........	4,179	......	....	......	....	....	......	4,123	......	....	....	25.36	......	....	91,784	189,399	....
1889........	12,123	......	....	......	....	....	......	12,123	......	....	....	23.10	......	....	120,503	295,892	50,000
1890........	19,477	......	....	......	....	....	......	17,678	......	....	....	19.30	......	....	168,939	382,080	200,000
1891........	24,547	......	....	......	....	....	......	25,760	......	....	....	14.08	......	....	181,590	387,107	200,000

BROKEN HILL PROPRIETARY COMPANY, AUSTRALIA.

Half Year Ending.	Mined Dry Tons.*n'*	Smelted.	Concentrated Tons.	Concentrated Leached Tons.	Smelted.				Ozs. Silver from Leachings.	Ore Sold.			Silver Rec'd per Oz. Cts.	Lead Rec'd per Lbs. Cts.	Total Ozs. Silver.	Total Expenditures. $	Total Receipts. $	Dividends. $
					Per Cent Lead Saved.	Ozs. Silver Saved per Ton.	Total Ozs. Silver Saved.	Total Tons Lead Saved.		Tons.	Ozs. Silver Saved.	Tons Lead Saved.						
Nov. 30, '85........	48	....	....	....	......	......	....	....	....	48	35,605	......	......	......	35,605	36,130	37,210	....
May 31, '86........	1,103	....	....	....	......	......	....	....	....	1,103	144,604	......	......	......	144,604	214,680	185,265	....
Nov. 30, '86........	10,397	10,397	....	....	19.2	83.8	871,665	1,991	....	......	....	......	100	3.00	871,665	404,785	786,075	240,000
May 31, '87........	18,411	18,411	....	....	15.4	45.4	835,526	2,836	....	......	....	......	97	2.98	835,526	682,815	1,022,795	400,000
Nov. 30, '87........	28,800	28,800	....	....	21.4	41.7	1,267,699	6,512	....	......	....	......	96	3.00	1,267,699	974,595	1,438,520	480,000
May 31, '88........	39,789	39,789	....	....	16.4	39.5	1,633,737	6,774	....	......	....	......	93	3.25	1,633,737	1,097,010	1,865,170	760,000
Nov. 30, '88........	54,336	54,336	....	....	17.3	40 0	2,290,455	9,885	....	......	....	......	93	3.11	2,290,455	1,387,855	2,561,835	960,000
May 31, '89........	68,545	68,545	....	....	16.1	37.7	2,677,686	11,417	....	......	....	......	92	2.92	2,677,686	1,595,245	2,929,485	1,200,000
Nov. 30, '89........	88,639	68,517	20,122	....	17.7	43.2	3,325,613	13,659	....	......	....	......	95	2.89	3,325,613	1,882,185	3,724,655	1,840,000
May 31, '90........	103,399	74,995	28,404	5,134	18.1	44 8	3,814,486	15,400	40,845	......	....	......	98	2.99	3,855,331	2,029,110	4,363,796	2,320,000
Nov. 30, '90........	103,912	84,306	19,606	16,756	16.2	40.2	3,697,196	14,939	175,350	......	....	......	108	3.22	3,872,546	2,223,625	4,873,790	2,640,000
May 31, '91........	138,645	132,498	2,713	4,102	17.5	35.5	4,796,342	23,624	16,865	3,434	104,917	598	100	2.99	4,918,124	2,840,435	5,677,845	2,880,000
Nov. 30, '91........	147,473	127,234	19,458	....	13.1	36.9	4,985,375	17,466	....	781	43,539	......	98	2.91	5,028,914	3,647,995	5,829,415	2,880,000
May 31, '92........	180,852	169,422	8,100	5,113	15.2	31.1	5,623,914	26,611	34,693	3,330	96,333	232	91	2.69	5,754,940	3,246,530	5,964,810	2,880,000
B. H. Totals and Averages...	984,349	877,250	98,403	31,105	16.3	38.9	35,819,694	151,114	267,753	8,696	424,998	830	......	......	36,512,445	21,356,235	41,260,690	19,480,000

Silver Mining Companies—Costs.

HORN SILVER MINE, UTAH.

Year.	Mining.	Prospecting.	Improvements.	Sundries.	Total.	Hauling.	Smelting Cost per Ton mined.	Refining Cost per Ton Smelted.	Grand Total Cost per Ton mined.	Cost per Oz. obtained by Milling.	Cost per Oz. sold in Ore.
	$	$	$	$	$	$	$	$	$	Cts.	Cts.
Feb. 17, '79 to Jan. 1, '82	5.15	...	4.73	4.39	14.27	42	24.05	11.30	44.80	...	...
1882	4.44	...	.68	.89	6.01	...	16.23	9.77	38.79	...	...
1883	...	...	...	...	...	...	...	...	...	...	...
1884–86	...	...	...	...	...	...	...	...	...	...	...
1887	17.74	...	...	45.38	63.12	...	...	...	63.12	...	...
1888	10.77	4.58	...	6.61	21.96	...	...	...	21.96	...	...
1889	6.76	.78	...	2.46	9.94	...	...	...	9.94	...	...
1890	5.65	.60	...	2.42	8.67	...	...	...	8.67	...	...
1891	4.92	.36	...	2.12	7.40	...	...	...	7.40	...	...

BROKEN HILL PROPRIETARY CO., AUSTRALIA.

Half Years, Ending:	Average Cost of Treatment per Ton.*l'*		Cost of Construction per Ton.*m'*							Cost Lead per lb.	Cost Silver per Oz.
	$		$						$	Cts.	Cts.
Nov. 30, 1885	484.00	...	269.00	...	...	...	...	...	753.00	...	...
May 31, 1886	110.00	...	85.00	...	...	...	...	...	195.00	...	...
Nov. 30, 1886	33.72	...	5.10	...	...	...	...	...	38.82	1.4	40
May 31, 1887	33.02	...	3.92	...	...	...	...	...	36.94	2.3	66
Nov. 30, 1887	28.97	...	4.76	...	...	...	...	...	33.73	1.9	57
May 31, 1888	22.53	...	4.98	...	...	...	...	...	27.51	2.0	50
Nov. 30, 1888	21.84	...	2.38	...	...	...	...	...	24.22	1.7	46
May 31, 1889	21.36	...	2.98	...	...	...	...	...	24.34	1.7	45
Nov. 30, 1889	18.83	...	.13	...	...	...	...	...	18.96	1.5	44
May 31, 1890	19.37	...	−.04	...	...	...	...	...	19.33	1.4	41
Nov. 30, 1890	21.40	...	1.12	...	...	...	...	...	22.52	1.5	46
May 31, 1891	19.51	...	−.09	...	...	...	...	...	19.42	1.4	44
Nov. 30, 1891	17.96	...	.75	...	...	...	...	...	18.67	1.6	42
May 31, 1892	18.42	...	.46	...	...	...	...	...	18.88	1.4	43
B. H. Totals and Aver	20.48	...	1.22	...	...	...	...	...	21.70	...	...

NOTES FOR TABLES OF SILVER MINING COMPANIES.

a Not reported. *b* Estimated. *c* The average production of gold "per annum" is about 2300 ozs.

d Sundries here include expense, account, and extraordinary disbursements, such as the purchase of claims, bills payable, expenditures, etc. *e* Dry tons. *f* Wet tons only reported.

g The Elkhorn Mining Co acquired this property Feb. 25, 1890, by purchase for $825,000.—In the table silver and gold are reported together, since in a total of 1,201,129 ozs. produced only 1343 were gold ozs.

h Includes proportionate amount of surface expenses and all other charges.

i The report for this year does not furnish the necessary information for the calculation of this cost.

j This cost is undoubtedly low, as it is calculated from the average cost of mining, while the cost for shipping ore will be above the average, owing to the extra expense of sorting.

k This is the total cost obtained by charging *all* expenses against the ozs produced. The lead contained in the ore sold to smelters represents so much additional profit, as the total expenses are charged against the silver and gold. *l* Milled by contract in the Algonquin Mill.

m Additional ounces over those obtained by milling were contained in ore sold direct, of which the ozs. were estimated.

n This cost includes New Hoist houses, engines, and boilers at Ruby & Cleveland shafts and compressor plant at Rumsey tunnel.

o Two reports were combined in order to charge the cost of improvement and other expenses against the production which ceased during the improvement and development period.

p Bleichert Tramway Construction.

q Cost per ton of ore delivered to mill "C" *only* by Bleichert Tramway.

r This cost is applied to *wet tons*, and is therefore *low*. *s* This cost includes mill "A" construction.

t This cost includes New Hoist and Compressor. *u* " " " " "B" "

v " " " Mill "C". *w* Part of Mill "G" addition.

x This average is for carbonate ores only, which in the preceding year averaged 40.4 ozs.

y Of this amount 4047 tons were taken from the dump, yielding $24,513, of which 61.1% was profit.

z This cost is exclusive of the proportionate cost for lead, as the proportionate valuation of the lead and silver was not obtainable.

a' The report merely states that this cost is $1.25 less than for any previous year.

b' McCormick Shaft Expenditure, $46,165. *c'* Emmet Shaft Expenditure. $51,774.

d' The receipts from interest, etc., here exceeded the charge for sundry New York office expenses.

e' The total *Mine Expenses* are given as $512,682.

f' Includes all mines receipts minus bullion expense, discount, and reclamation.

g' Includes property purchase of $224,360.

h' Includes expenditure for the construction of Shaft No. 2, Drain Tunnels No. 1 and 2.

i' Includes purchases of Home Coal Co.; stock and money advanced.

j' This cost does not agree with the total of mining and milling, because it represents the total cost per ton mined, whether milled or sold direct, and includes the cost of all operations and purchases at the mines of whatever nature. *k'* Includes payment of $107,337.50 for R. R. iron in 1880 *l'* Includes depreciation.

m' Includes construction minus depreciation for the year; the minus quantities, therefore, indicate that the estimated depreciation exceeds the actual expenditure. *n'* Tons of 2240 lbs.

ALASKA TREADWELL GOLD MINING COMPANY.*a*

Year.	Tons Crushed. *h*	Oz. per Ton.	Total Oz.	Chlorinated.			Aver. Oz. per Ton.	Grand Total Oz.	Total Ex-penses.	Total Profits.	Divi-dends.	Costs per Ton Milled.*g*							Cost per Oz. Gold.
				Tons conc't's	Oz. per Ton.	Total Oz.						Min-ing.	Im-prv't.	Sun-dries.	Total Min-ing.	Mill-ing.	Total Milling.	Grand Total.	
1882–1884	....	.....	528	....	.....	....	.....	528	....		....	......	......	.....	......	......	....	....	....
Aug. to Dec. 1885	34,495	.33	11,232	205	2.40	491	.34	11,723	....		....	......	......	.....	......	......	....	....	....
Jan. to Dec 1886	90,826	.15	13,728	1,566	2.55	3,988	.20	17,716	....	$729,000	....	......	......	.....	......	......	....	....	....
Jan. to Dec. 1887	108,306	.15	16,615	1,697	3.81	6,459	.21	23,074	....		....	......	......	.....	......	......	....	....	....
Jan. to Dec. 1888	121,173	.14	16,849	1,354	2.92	3,949	.17	20,798	....		....	......	......	.....	......	......	....	....	....
Jan. to Dec. 1889	214,544	.12	25,157	2,527	2.14	5,410	.15	31,567	$344,491	$308,000	....	......	......	.....	......	......	....	....	....
Jan. to May 1890	47,768	.10	4,900	1,516	1.90	2,874	.16	7,774	122,682	38,000	....	......	......	.....	......	......	....	....	....
June, 1890, to May, 1891	220,686	.12	25,699	5,869*b*	2.02	11,544	.17	37,243	371,793	418,209	$200,000	......	.15	.18	1.04	.42	.64 *c*	$1.68	$ 9.88
June, 1891, to May, 1892	239,633	.10	24,620	6,177	1.52	9,614	.14	34,234	359,280	361,980	450,000	.63	.13	.17	.93	.38	.57 *c*	1.50	10.71
Total	1,077,431	.13	140,326	20,910	2.12	44,327	.17	184,653	....	....	....	......	......	.....	......	......	....	....	....

a The Paris mine was owned by the Alaska Mill and Mining Company up to June 1, 1890; since that date it has been owned and operated by the Alaska Treadwell Gold-mining Company.

b Includes 501 tons sold direct.

c These totals include the cost of chlorination, 22 and 19 cents, respectively, for each ton of ore milled. The cost per ton of concentrates is only obtainable for two years and is as follows:

	Labor.	Supplies.	Total.
June, 1890, to May, 1891	$5.03	$3.99	$9.02
June, 1891, to May, 1892	4.80	2.81	7.61

d This cost is for working expense only.

e Sundries includes transportation of bullion, taxes, general expense, etc.

f This cost includes mining, milling, improvements, and conveyance of bullion to and coin from Bolivar. It is exclusive of office and general expense at Bolivar, bullion expense, exchange, and property purchase.

g Mining costs are charged to the tons milled as the tons mined, are only roughly estimated, and the tons crushed, which are nearly equal year by year to those mined, appear to furnish a more reliable basis for computation of this cost.

h Tons of 2000 lbs.

i Data insufficient for calculation of this cost.

j This expenditure is for working expense *only*, and is exclusive of permanent improvements.

k Includes permanent improvement charged to capital account in the reports.

l The cost of production of gold and silver is obtained by charging to each its proportion of the total expenditure, in the ratio of the *assay values* of their respective products.

The foregoing tables give in condensed form a vast amount of information deduced from data distributed throughout the annual reports of a number of prominent gold and silver mining companies. Unfortunately, few mining companies keep their accounts in a clear, itemized, or systematic manner. There is no other department in this industry that so greatly needs reform as does the accounting. There is absolutely nothing to be gained by making a secret of costs in mining gold, silver, copper, lead, iron, etc.; and whenever a secret is made of these items it is almost always to cover some pet extravagance or some downright dishonesty. These tabulations are far from being exhaustive analyses of the accounts of the several companies, but they give nearly all the information the official reports afford.

EL CALLAO GOLD MINING COMPANY (VENEZUELA, SOUTH AMERICA).

Year.	Tons Crushed. h	Gold Oz. per Ton.	Total Gold Oz.	Silver Oz. per Ton.	Total Silver Oz.	Total Expenses. f	Total Profits.	Dividends.	Costs per Ton Milled. g									Cost per Oz. Silver.	Cost per Oz. Gold.
									Min-ing.	Pros-p'ct'g	Im-prv't.	Sun-dries. e	Total Min-ing.	Mill-ing.	Im-prv't.	Total Mill-ing.	Grand Total.		
1871–1880	85,986	3.58	307,495					$1,520,000											
1881	24,978	2.89	72,255					360,640									32.26d		11.16d$
1882	22,405	4.70	105,396					991,760									39.52d		8.41d
1883	27,586	4.87	134,363					1,207,100									40.14d		8.24d
1884	30,936	5.72	177,055			$1,115,000		1,932,000	17.77	4.23		1.49	23.49	7.51	5.04	12.55	36.04		6.30
1885	47,223	2.42	114,454			1,031,242		914,480	12.38	2.33	.07	1.13	15.91	5.12	.81	5.93	21.84		9.02
1886	73,708	2.45	181,040					2,202,480									15.10d		6.16d
1887	66,167	1.11	73,864			888,241		296,240	11.21			.45	11.66	1.76		1.76	13.42		12.07
1888	54,152	.87	52,599			846,382		25,760	13.12			.49	13.61	2.02		2.02	15.63		17.97
1889	57,301	.91	52,974			765,658		103,040	10.52	.86		.44	11.82	1.54		1.54	13.36		14.68
1890	53,066	.93	49,430					103,040									13.78d		14.82d
1891	58,949	.59	34,775			594,064			4.69	3.57	.12	.27	8.65	1.37		1.37	10.02		16.98
½–1892	31,059	.63	19,743			331,113			4.40	2.89	.29	.95	8.53	1.18		1.18	9.71		15.41
Total	630,486	2.26	1,375,459																

MONTANA COMPANY, LIMITED (DRUMLUMMON MINE).

Year.	Tons Crushed.	Gold Oz. per Ton.	Total Gold Oz.	Silver Oz. per Ton.	Total Silver Oz.	Total Expenses.	Total Profits.	Dividends.	Min-ing.	Pros-p'ct'g	Im-prv't.	Sun-dries.	Total Min-ing.	Mill-ing.	Im-prv't.	Total Mill-ing.	Grand Total.	Cost per Oz. Silver.	Cost per Oz. Gold.
	h					k											k	k and l	k and l
1883	987	1.33	1,312	29.6	29,196														
1884	19,133	.37	7,127	5.2	100,191			$ 47,670											
1885	33,482	.77	25,939	8.3	277,540	$395,436$j$		245,120									11.81j	.57j	9.15j
1886	41,728	1.06	44,341	14.8	617,356	773,855	$552,000	701,250	i	i	1.17	i	i	i	4.88		18.55	.58	9.42
1887	75,005	.78	58,263	8.7	656,115	746,622	837,910	907,500	i	.91	.78	i	i	i	.30		9.95	.47	7.56
1888	83,745	.42	34,941	3.4	288,659	652,257	315,575	288,750	3.10	.83	1.17	.26	5.36	2.34	.09	2.43	7.79	.71	12.32
1889	78,749	.48	37,944	5.1	404,249	751,124	309,125	288,750	3.83	1.12	1.22	.52	6.69	2.72	.13	2.85	9.54	.74	11.88
1890	81,735	.44	35,670	3.4	279,104	751,057	154,750	165,000	2.37	1.19	1.00	1.68	6.24	2.95		2.95	9.19	.89	14.11
1891	80,274	.35	28,402	1.6	129,953	640,778	53,580	41,250	2.65	1.00	.85	1.30	5.80	2.16	.02	2.18	7.98	1.08	17.60
½–1892	42,150	.24	10,236	.9	38,232	268,433	–13,045	0	2.52	.38	.53	1.09	4.52	1.80	.05	1.85	6.37	1.33	21.24
Total	536,988	.53	284,222	5.2	2,806,579														

The cost of producing silver and gold at these mines should not be taken as a measure of the average cost of all the metal made in this country or in Australia, for these are among our great and cheap mines. As has been stated elsewhere in this article, the average cost of producing either metal depends on the quantity specified. If this should be only 5,000,000 oz., then that amount could be supplied, by mines temporarily in bonanza, at a very small cost, possibly 25c. an ounce. If 60,000,000 oz. were called for, the average cost at which the metal could be produced in one year by the lowest-cost mines

would probably be about 77c. per oz. If 100,000,000 oz. were required, the average cost would probably run up to $1.29 per oz. There is no even progression in these figures; they depend more upon the finding of bonanzas than upon the cost of mining and milling, concerning which we have accurate data.

In well-established and economically managed mines and mills the actual cost of mining, crushing, amalgamating, retorting, etc., in a free-gold mill may be taken as a minimum at the Deadwood-Terra mine in South Dakota, where it is about $1.25 per ton of ore, 500 tons a day are crushed by 160 stamps. At the Alaska Treadwell Company the average total cost last year was about $1.50 per ton on a very large output. Where veins are smaller and output less, the cost increases. With the large low-grade ore bodies which are destined to furnish the greater part of the precious metals in the future, the costs at well-located mines and mills may be roughly estimated at $2 a ton for mining and $3 a ton for barrel chlorination or for treatment by the cyanide process on ores adapted to each, and from which 90% of the metal can be saved. The necessity for extra handling of the ore, for a more expensive treatment, irregularities in the ore bodies, and changes in the ore itself, or any of a number of other causes, may easily bring the total cost up to $10 a ton or over. In the large mines cited in the foregoing tables this total varies from $1.50 per ton up to very high figures, and may roughly be averaged, as at present, at about $20 a ton.

If the cost of unsuccessful mines and the money lost in unfruitful prospecting and other unprofitable investments made in the expectation of finding a bonanza were to be included in the cost of the silver or gold produced each year, no doubt the figures would amount to far more than the market price of either metal. And this would be especially true when the market price was high, for then the prize in the lottery being greater,—that is, the value of a bonanza being increased,—a vastly greater amount would be expended in the search for one and in wild speculation and investment in the expectation that each new vein would become in depth "a second Comstock." It would be just as reasonable to charge up as a part of the cost of making pig-iron all the money lost in speculative purchases of undeveloped ore lands or that vast amount expended in the various more or less unsuccessful efforts to produce wrought-iron at $10 a ton by the direct-reduction processes.

In an economic and commercial sense no difference can be made in the method of estimating the cost of producing any of the metals. It is always the actual minimum cost at which the quantity demanded by the market can be supplied. A small surplus of any metal establishes the market value of the whole, and those who cannot meet this market, whether their product be gold, silver, or copper, are unfortunate, but should no more expect the whole world to pay a price for their product that would be profitable to them than they would be willing to pay double the market price for any other article because some of its producers were losing money through their lack of natural advantages or from the improved methods of production adopted by their competitors. Moreover, no matter what the market prices of gold, silver, copper, etc., may be, mines and ores will be worked which leave no profit, in the never-failing expectation that the market will rise again, or that the ore will become more abundant or richer.

Chronology of the Gold and Silver Industry, 1442–1892.

By Walter Renton Ingalls.

The following chronology, compiled from various authorities, forms a brief history of the gold and silver mining industry for a period of 450 years, together with a record of the changes in the monetary position of the two metals. The dates given are believed to be in the main accurate, and are of interest in connection with the statistical tables of production.

1442: Gonçales Baldeza returned from a voyage to regions about Bojador, West Africa, bringing with him the first gold from the western coast of that continent.

1471: The silver mines at Schneeberg, Saxony, were first worked; up to 1500 the yield is estimated to have been more than 160 tons (163,000 kilos) of silver, but after that year the output decreased rapidly.

1492: Discovery of America by Columbus, whose chief object of search was gold, which he found in considerable quantity among the natives of the islands he reached.

1516: The silver mines at Joachimsthal, Bohemia, were in flourishing condition at the beginning of the sixteenth century. In 1516 some 8000 miners were employed there.

1521: Conquest of Mexico by Hernando Cortés.

1522: The first silver sent to Europe from the mines of Mexico was obtained from Tasco, discovered by the Spaniards this year. These mines together with those of Pachuca are considered the oldest in Mexico, some of them having been long worked by the Aztecs at the time of the arrival of the Spaniards.

1527: There are no documents to show when silver-mining was first begun at Przibram, Bohemia, but, according to the municipal records, a concession to reopen the mines was granted in 1527.

1532: Conquest of Peru by Francisco Pizarro.

1537: Gold-mining was begun by the Spaniards in New Granada (United States of Colombia).

1540: Work was begun by the Spaniards in the silver mines of Zacatecas, Mexico.

1545: Discovery of the famous silver mines of Potosí, Bolivia.

1548: First discovery of silver at Guanajuato, Mexico.

1555: The silver mines at Sombrerete, Zacatecas, Mexico, began to produce.

1557: Invention of the patio process of silver amalgamation by Bartolomé de Medina, of Pachuca, Mexico.

1571: The Huancevalica quicksilver mines in Peru first began to produce in noteworthy quantity. This was an important event, as an abundant supply of mercury for the amalgamation of Potosí ore was thereby obtained.

1574: The patio process was introduced in Peru.

1575: Discovery of the silver mines of Oruro, Bolivia.

1577: The placers of Brazil were first discovered this year, but they were not actively worked until 1674, and their product did not begin to be important until 1695.

1590: Invention of the system of copper-pan or "cazo" amalgamation by Alonzo Barba, at Potosí, Bolivia.

1609: Holland maintained from 1609 to 1816 a silver monetary standard, giving gold a nominal valuation at a ratio of 14.7 to 1.

1623: Discovery of silver at Kongsberg, Norway; the works at that place were established the same year.

1630: Discovery of the famous silver mines of Cerro de Pasco, Peru.

1632: Discovery of the silver mines of Batopilas, Chihuahua, Mexico.

1633: Invention of the aludel furnace for the reduction of quicksilver, by L. S. Barba, a Peruvian; this was the first efficient furnace devised for this purpose.

1666: Discovery of the silver mines of Cusihuiriachic, Chihuahua, Mexico.

1688: Silver was the legal measure of value in Hamburg, a city of extensive commerce, from 1688 until recent times, but gold also was coined at a ratio of 14⅝ to 1.

1695: The rich placers of Minas Geraes, Brazil, began to produce largely.

1702: Establishment of the school of mines at Freiberg, Saxony.

1704: Discovery of the silver mines of Santa Eulalia, Chihuahua, Mexico.

Discovery of silver at Nertschinsk, Siberia, and the first regular mining of precious metals in that country was begun.

1710: The metallurgical works at Freiberg, Saxony, were consolidated.

1717: From 1717 to 1816, the legal ratio between gold and silver in England was 15½ to 1.

1737: Discovery of gold near Voitsk, Government of Archangel, Russia.

1745: Important discovery of gold-bearing quartz on the Beriozofsk River, near Ekaterinburg, in the Ural, Russia. Gold-mining was also commenced on Snake Mountain, in the Altai Range, Siberia.

1762: Discovery of the great silver bonanza of Real del Monte, Mexico.

1771: Discovery of the rich silver mines of Hualgayo, Peru.

1774: The first placers in the Ural were discovered this year, quartz lodes having been opened nearly thirty years previous.

1778: The silver mines of Catorce, Mexico, were opened and proved to be rich.

1783: Zambrano discovered the famous silver mines of Guarisamey, Durango, Mexico.

1786: Prior to the Constitution of 1789, the Congress of the American States had, in 1786, established a double monetary standard with a ratio of 15¼ to 1, fixing as unit the dollar of pure silver of 375.64 grains.

1790: Barrel amalgamation was introduced at the metallurgical works at Freiberg, Saxony.

1792: The famous bonanza at Sombrerete, Zacatecas, Mexico, was discovered this year, the mines at that place having been worked for more than two centuries.

The legal ratio between gold and silver in the United States was made 15 to 1, by the act of Congress creating a mint.

1793: Mules and horses were used in Mexico, for the first time, for mixing the pulp, mercury, and chemicals in the patio process, saving 75% in the cost of this branch of working; prior to this time, the operation had been performed entirely by human labor.

1798: Discovery of the great bonanza (silver) at Ramos, Mexico.

1803: France adopted the double monetary standard at a ratio of 15½ to 1;

previous to the Revolution, the ratio between gold and silver in that country had been 15 to 1.

1805: The gold mines of the Ancosta district, Bolivia, commenced to yield.

1810: Discovery of silver at El Refugio, Chihuahua, Mexico.

1816: Discovery of the Melkowa placers, Siberia.

England adopted the gold standard by act of Parliament of this year.

Silver was the sole standard in Holland until this year, when the double standard was adopted at a ratio of 15.873 to 1.

1821: Resumption of specie payments in gold by the Bank of England.

1824: Discovery of silver at Palmarejo, Chihuahua, Mexico.

The silver mines of Fresnillo, Zacatecas, Mexico, were opened.

1829: Discovery of gold mines in Georgia; first mining excitement in the United States.

1830: Discovery of the placers of the Altai Mountains, Siberia.

Discovery of the silver mines of Guadalcañal, Spain.

1832: The silver mines of Chañarcillo, near Copiapo, Chile, were opened.

1834: The legal ratio between gold and silver in the United States was made 16 to 1.

1837: The St. John del Rey Mining Company, operating the Morro Velho gold mine in Brazil, commenced to produce largely.

1839: Count Strzelecki is said to have found gold in New South Wales in 1839, but in deference to the wishes of the Governor, Sir G. Phipps, the discovery was kept secret, the colony being then a penal one. In 1841, Rev. W. Clark also found gold, and in 1847 he called the attention of the colonists to the auriferous character of the country. The value of the diggings was not realized, however, until Hargreaves made his discovery in 1851.

1843: The Augustin process of working silver ores was introduced at the Gottesbelohnung Hütte, near Mansfeld, Germany, and later in the year at the Freiberg works.

Discovery of the silver mines of Hien de la Encina, in Guadalajara, Spain.

1847: Holland again adopted the silver standard.

1848: On January 19, Marshall discovered gold at Coloma, Cal. This find started the rush of gold-seekers to the Pacific Coast, and by the end of the year numerous discoveries of the precious metal had been made in various portions of the State, notably along the American and Feather rivers.

The Ziervogel process for treating silver ores was introduced at Freiberg, superseding the Augustin process.

1849: Discovery of gold in the bed of the Yuruari River, Venezuela, but the region did not become the scene of great operations until several years later.

Discovery of gold in Gold Cañon, Nevada; an important event, as it eventually led to the discovery of the Comstock lode.

1850: Belgium adopted the single silver monetary standard.

Quartz-mining was begun in California.

1851: Discovery of gold in New South Wales by Hargreaves.

Discovery of gold at Ballarat and Bendigo, in Victoria, following close upon the discoveries in New South Wales.

Work was begun at the quicksilver mines of New Almaden, California.

1852: Discovery of gold in South Australia and Tasmania.

Invention of the process of hydraulic mining in California by Edward E. Mattison, a native of Connecticut.

1857: Discovery of gold in New Zealand.

Suspension of specie payments by Russia.

The German States, including Austria, adopted a single silver standard.

1858: Discovery of gold at Canoona, Queensland.

The Patera process was introduced at Joachimsthal, Bohemia; the use of sodium hyposulphite as a lixiviant for silver ores having been first suggested by Dr. Percy in 1848.

1859: The Comstock lode, Nevada, was discovered early in the year by O'Reilly and McLaughlin, at the point where the Ophir mine is located. The Grosh brothers found silver in this vicinity several years previous, but their discovery came to naught.

Discovery of gold in the Fraser River region, British Columbia.

Pike's Peak excitement; discovery of gold placers in Gilpin County, Colorado, in California Gulch, and at Breckenridge.

1860: Invention of the Washoe process of pan amalgamation by Almarin B. Paul and James Smith.

Discovery of the Gould & Curry and Savage bonanzas in the Comstock lode.

Discovery of the placers of the Boisé Basin in Idaho.

After seventeen centuries of neglect the silver-lead mines of Laurium, in Greece, were reopened, a French company having obtained a concession of the property.

1861: Belgium returned to the double monetary standard.

Discovery of gold in Nova Scotia.

Discovery of rich placers in Oregon.

1862: Suspension of specie payments by the United States.

First important discoveries of gold in Montana.

Discovery of silver in the Reese River district, Nevada.

1863: First discoveries of argentiferous lead ores in Little Cottonwood Cañon, Utah.

1864: First locations at Eureka, Nevada, but no important discoveries (silver-lead) were made until the fall of 1869. Claims were also located at Pioche, in the same State, though operations at that place did not become successful until several years later.

Discovery of rich placers in Last Chance Gulch, Montana; placers were also located at Butte.

Discovery of the Yellow Jacket-Kentuck-Crown Point and Belcher bonanzas in the Comstock lode.

1865: Establishment of the Latin Union, consisting of France, Italy, Switzerland, and Belgium, providing for a double monetary standard at a ratio of 15½ to 1, the agreement to hold good until 1880.

Discovery of the silver lodes at Phillipsburg, Deer Lodge County, Montana, but it was not until 1881 that the great Granite Mountain mine began to develop into a bonanza.

Discovery of the Chollar-Potosí bonanza in the Comstock lode.

1866: Italy suspended specie payments.

Discovery of the Overman-Segregated Belcher-Caledonia and Hale & Norcross bonanzas in the Comstock lode.

Discovery of the famous El Callao mine, Yuruari district, Venezuela.

1867: First international monetary conference convened in Paris by the French Government, at which twenty nations, comprising all the important countries of Europe and America, were represented.

Discovery of rich deposits of silver ore at White Pine, Nev.; these were the first large bodies of silver ore found in a limestone formation in the United States, and the information gained from them led directly to the discovery of the silver-lead deposits of Eureka soon afterwards.

The smelting works of the Boston & Colorado Smelting Company were established at Black Hawk, Colorado; this was an important step for the development of the mines of Gilpin County and other districts in Colorado.

Discovery of the Thames gold-field on the north island of New Zealand.

1868: Greece joined the Latin Union.

Discovery of gold in Western Australia, but it was not until 1887 that any diggings of importance were found.

The Emma silver mine, Little Cottonwood, Utah, was located in August of this year, but no large shipments were made until July, 1870.

Discovery of the Sierra Nevada bonanza in the Comstock lode.

1869: Discovery of the important silver-lead deposits of Eureka, Nevada. The American practice of lead smelting has been developed chiefly from the methods adopted in this district.

The Pacific Railway was completed, and prospecting along its line was greatly stimulated.

The Sutro tunnel to open the Comstock lode was commenced Oct. 19.

Discovery of promising deposits of silver ore at Pioche, Nev.

Copper-silver ore was discovered at Butte, Montana, and a smelting furnace erected at the Parrott mine.

1870: Great silver deposits were discovered at Caracoles, about 120 miles inland in the desert province of Atacama, Chile, on the Bolivian frontier.

The silver mines of Eureka and Pioche, Nevada, became large producers.

1871: The German Empire, by Act of Dec. 4, assumed the sovereign right of coinage and adopted the gold standard; the mintage of silver was discontinued.

Discovery of the great Crown Point-Belcher bonanza in the Comstock lode.

The mines of Big and Little Cottonwood, Utah, made large shipments.

1872: Discovery of silver at Georgetown, New Mexico.

The Ontario vein (silver), Park City, Utah, was located June 19.

1873: The United States, by Act of Congress, Feb. 12, discontinued the coinage of silver dollars. This Act did not demonetize silver in words, although it did so in effect. The silver dollar is not named in it. Precisely what the Act did was to authorize the coinage of silver half-dollars, quarter-dollars, and dimes below standard weight, and of a new silver coin for Asiatic commerce, of standard weight, to be called the "trade dollar," and to prohibit these coins from being legal tender for more than five dollars in any one payment.

Discovery of the "Big Bonanza" in the Consolidated California & Virginia mines on the Comstock lode.

The German Government, by Act of July 9, provided for the retirement of its silver coins and the sale of the bullion.

By a Treasury order, Sept. 6, France limited the amount of silver to be accepted by its mint.

1874: A year of great excitement on the Comstock, the "Big Bonanza" beginning to yield largely, while another bonanza was discovered in the Ophir mine.

Silver was demonetized by the Scandinavian States.

Discovery of promising silver mines, including the Silver King, in the Pinal Range, Arizona.

Early in the year argentiferous lead-carbonate ore was found on Iron Hill, Leadville, and the Lime and Rock claims were located.

By an agreement made in January of this year, the Latin Union was to limit the coinage of silver, exclusive of subsidiary coins, to the following sums for three years: 1874, 140,000,000 francs; 1875, 150,000,000 francs; 1876, 108,000,000 francs. Any nation in the Union had the right to decline coining its quota of this amount any year.

1875: Holland, by Act of June 6, suspended mintage of silver for private account, and established gold coinage with unlimited legal-tender functions, with a ratio of 15.604 to 1; this was a provisional law, to last only until Jan. 1, 1877.

Switzerland declined to coin its quota of silver assigned by the agreement of the Latin Union.

1876: First shipments of silver-lead ore from Leadville, Colo.

Discovery of silver-lead ore at Frisco, Utah, and the Horn Silver mine was opened this year.

In July was brought the first suit of the farmers in California against hydraulic miners, and from this time the débris question became a burning subject of discussion.

The gold-fields of Black Hills, Dakota, began to attract much attention.

Discovery of the Drumlummon ledge (gold) at Marysville, Mont.

Belgium suspended the coinage of silver.

France discontinued the mintage of silver, except for subsidiary coins, until January, 1878, by proclamation of the President, in accordance with the Act of August 5, 1876.

A royal decree was issued in Spain interdicting the coinage of silver except on Government account, and declaring it to be the intention of the Government to limit the legal-tender function of silver to 150 pesetas (about $30) after it had obtained a sufficient amount of gold to make this step practicable.

Russia suspended the coinage of silver for individuals, excepting the amount of silver money needed for trade with China.

By Act of Congress of the United States, August 15, a silver commission was created which reported on March 2, 1877.

1877: Discovery of rich silver veins at Silver Cliff, Colorado, including the Bassick and Bull-Domingo mines.

The curious argentiferous sandstone deposits of Silver Reef, Washington

County, Utah, had been known since 1871 and a mining district was organized there in 1874, but the mines did not commence to produce until 1876.

1878: On Feb. 28, the Congress of the United States passed an Act ordaining the coinage ($2,000,000 per month at least, $4,000,000 at most) on Government account of silver dollars of 412½ grains, 900 fine, and made them full legal tender except where expressly stipulated otherwise by contract.

An international monetary conference was held in August at Paris.

Great excitement at Leadville, Colo., where many new discoveries were made.

The first locations at Tombstone, Ariz., were filed, and the next year the mines (silver) there commenced to produce largely.

Discovery of the silver-lead deposits of Sierra Mojada, Coahuila, Mexico.

1879: The German Government discontinued its sales of silver on May 16.

Resumption of specie payments by the United States.

Discovery of promising veins of silver ore at Aspen, Colo., and in the San Juan region in the southwestern part of the same State.

1880: Reported existence of promising gold veins in the Colar fields of Mysore, Southern India, which were subsequently opened and became large producers.

1881: Discovery of silver ore at Lake Valley, New Mexico.

First important discoveries of silver ore in the Calico district, California.

1882: Decision of the courts prohibiting hydraulic mining in the valleys of navigable rivers of California.

1883: The Mount Morgan gold mine, at Rockhampton, Queensland, began to produce.

The Broken Hill mine (silver-lead) in New South Wales, Australia, was discovered in September.

1884: Discovery of gold in De Kaap district of the Transvaal, South Africa.

1885: Discovery of the silver-lead deposits of the Cœur d'Alene region, Idaho.

The first important discoveries in the "banket" formation, Witwatersrand, Transvaal, South Africa, were made during this year, but active operations were not commenced until 1887.

1890: Act of Congress, July 14, repealing the law of 1878 and providing for the purchase of 4,500,000 ounces of silver monthly, against which certificates are issued, redeemable in either gold or silver.

Establishment of the silver-lead smelting industry in Mexico.

1891: The gold-fields of Mashonaland, South Africa, began to attract attention.

Large exports of gold from New York and purchases by Russia.

Discovery of silver ore at Creede, Colo., and gold at Cripple Creek, in the same State.

1892: The price of silver reached 82 cents per oz., the lowest point ever recorded.

Austro-Hungary adopted the gold monetary standard.

Third international monetary conference held in Brussels on invitation of the United States, adjourning in December without result.

At the close of the year large exports of gold from the United States, causing a very unsettled feeling in financial affairs.

UNIVERSAL BIMETALLISM AND AN INTERNATIONAL MONETARY CLEARING-HOUSE.

The following plan was proposed in the *Engineering and Mining Journal* of Dec. 3, 1892: "No effective or durable plan for universal bimetallism can be based upon the purchase of a limited amount of silver; all that is offered must be taken and paid for in gold or its equivalent. No plan which does not unite the interests of the participants and remove any inducement to violate it can be permanent.

"The plan proposed calls for the appointment by the nations of an International Monetary Clearing-House, with powers:

"1. To ascertain periodically the amount of money—that is, of gold, silver, and uncovered notes—held by each country during the preceding one or two years. These amounts are to form the basis for the proportions in which the several nations will join in the purchase of all silver offered.

"2. To clear every national transaction in the purchase or sale of money.

"3. To purchase, for common account, such an amount of silver (say 25% of their holdings) from each of the silver-basis countries as is necessary to put it on the gold or bimetallic basis.

"4. To issue international certificates, redeemable in gold or silver, at holder's option, against the gold and silver purchased.

"5. To determine from time to time what, if any, change in the value-ratio of gold and silver is called for by the changed conditions of production.

"6. To publish the transactions of the monetary clearing-house daily or weekly.

"This clearing-house, composed of one or more representatives of each country, would be a permanent expert commission, and would act through the mints of the several countries as depositories. This plan would render the interests of all nations identical, would put and maintain all on the gold basis, and would increase beyond any limit that has ever been suggested the facilities for international commerce, and practically increase in an enormous degree the availability or usefulness of the world's supply of money.

"The amount of money, that is, of gold, silver, and uncovered notes, in the world is, in round numbers, approximately $10,000,000,000, of which France holds about 17%, the United States 16½%, Germany 9%, the United Kingdom 7%. England's quota in the purchases of silver would therefore be but 7%. India would sell, say, $200,000,000 of silver for gold, of which England would get $14,000,000. The other silver countries would require about $100,000,000 of gold to put them on the bimetallic basis, and this would at once increase enormously the value of their securities held by Europe."

In other words, this plan contemplates the adoption by all participating nations of bimetallism; the acceptance of a basis for the purchase of a certain amount of silver from the silver-standard countries; the agreement to "clear" all national monetary transactions through a clearing-house. The whole question of ratio, apportionment of the precious metals purchased among those wanting them, and the surplus among all, and the many other working details of the plan would be in the hands of eminent trained experts devoting themselves specially to these questions and better able to solve them wisely, than are the legislators who are influenced by personal interests or national jealousies.

Discussion of this plan is invited by the *Engineering and Mining Journal.*

Recent Improvements in Gold Chlorination.

By John E. Rothwell, M.E.

Two years ago* I described the practical chlorination of gold ores on a large scale, by the barrel process, as then practiced. While no marked changes have been made in the general plan since then, there have been many improvements in details of the work, increasing the capacity, lessening the cost of treatment, and giving a plant of large capacity under minimum roof area. In this article I purpose giving the general arrangement and construction of such a plant—a "composite" plan, as it were, embodying parts of several plants.

The mill, roaster, chlorination, and power buildings are erected on level ground; the main ore bins, large crusher, and dryer on benches cut in the side-hill. The ore from the mine comes in cars to the top of the main ore bin, which has a capacity of about 1000 tons. The ore from the bin first goes over a quizzly with 1½ in. spaces into the coarse crusher, where it is broken to 1½ in. size. From the crusher it joins that which has passed the quizzly and runs into the revolving dryer, which is a cylindrical shell of ⅜-in. tank-steel, 5 ft. in diameter and 18 ft. long, set up on two heavy cast-iron tires, 4 ft. from each end. These tires rest on adjustable flanged rollers; the roller-frames are bolted to a heavy timber frame, to one end of which is fastened a pivotal casting, while the other end has a set of jack-screws, to permit any desired change in the inclination of the cylinder. The cylinder has usually one inclination of from ¾ to 1 in. per ft., and is revolved by a spur gearing around its exterior, with an intermediate gearing of cone pulleys and friction clutch, which give a range of speed of three-quarters to two revolutions per minute. The friction clutch allows the dryer to be stopped without stopping the mill, and is much simpler than a tight and loose pulley and shifting belt.

To increase the drying capacity the cylinder is divided into four longitudinal compartments by duplicating of plate-iron, ⅜ in. thick, bolted to angle irons riveted to the shell and an X iron in the center of the cylinder. The compartments are 14 ft. long, and 2 ft. from each end of the cylinder.

The furnace is built of masonry well strapped with iron, and with ample air passages around the fireplace, and in the bridge-wall, through which a large volume of air can be passed and heated before entering the cylinder. The dust chamber is similar to but not quite as large as that of the roaster, to be described later. From the dryer the ore passes by gravity to the fine crusher, where it is crushed to pass through ¾-in. mesh, and is then raised by a chain elevator to the first screen.

This is double, with a coarse mesh within a fine mesh, the object being to protect the latter from undue wear. The screen is hexagonal in form, 9 ft. long, 4 ft. 6 in. outside diameter at one end, and 5 ft. 6 in. diameter at the other; the inner screen is 12 in. less diameter at each end. The frame of the screen is a cast-iron hub with six radial arms of 1-in. round iron, reduced to ¾ in. near the ends. Two of these hubs are keyed on the ¾-in. shaft, together with the cast-iron

* *Engineering and Mining Journal*, Feb. 7, 1891.

head-piece. The mesh frames are slid in place in grooved cast-iron pieces fastened to the radial arms of the screen frame. They are interchangeable, and there are always three spare ones on hand. The screen makes 8½ revolutions per minute. The outside casing is made of double thickness, plain lumber inside, and groove and tongue outside, with paper between. The doors, one at each side and one at the end, are hinged to the frame of the casing.

The ore that passes the finer mesh goes to an elevator and is discharged into the storage bins; the rejected ore goes by a chute to a large hopper over the coarse rolls (26×15 in., with heavy steel tires), which are driven by belts 90 revolutions per minute. The ore from rolls is elevated to the main sizing screens, of which there are two of the same construction as the one already described, except that they are but 12 ft. long and are driven with bevel gearing and clutch to each screen, so that in case of needed repairs one can be stopped, the whole quantity of ore being sent to the other. The finished ore goes to the storage bins; the coarse to the fine crushing rolls, which are of the same size as the coarse, and return again to the screens.

The rolls are fed by automatic feeders, while an exhaust fan draws the dust away and discharges it into a collector on the top of the ore bins. The storage bins are placed along one side of the mill building and have a capacity of about 200 tons of crushed ore; a conveyor carries the ore from the bins to the roasting cylinder. The latter is a cylindrical shell of ⅜-in. plate, 36 ft. long and 5 ft. diameter, with 5 tires on which it revolves. The tires, adjustable rollers, spur, pinion, and other gear are the same as used under the dryer, so that it is only necessary to keep one set of extra parts. The shell is lined throughout with fire-clay blocks 6 in. thick, molded to fit the circle; it has projecting shelves the whole length of the cylinder, which raise the ore and shower it through the hot oxidizing gases in the upper part of the cylinder. At the end exposed to the fire a further protection is given to the shell by using a specially shaped block, that overlaps the end of the plate and is held in place by a small square piece of bar-iron fastened to the shell and which fits into a groove in the block. The inclination of the cylinder is 14 in.; it revolves once a minute.

The dust chamber, which is arranged to feed the dust back into the roasting cylinder, is hopper-shaped on three sides, the bottom of the hopper being an inclined cast-iron plate projecting into the upper end of the cylinder about 8 in. The dust carried out of the cylinder settles in this chamber, and as it accumulates slides down the sides and mixes with the fresh ore. This arrangement does away with the old auxiliary fireplace and the expensive rehandling of the dust, besides giving the ore to the chlorinators in a much more uniform condition than when the dust is mixed with the ore by hand. From the dust chamber the gases pass up an inclined flue on the side-hill to a stack 42 in. diameter and 60 ft. high.

The furnace fireplace is constructed with air channels and openings through which the temperature and working of the cylinder can be regulated and watched. The fire arch and bridge wall are so constructed that the flame is directed into the lower part of the cylinder and against the ore as it slides down on the lining. The roasted ore is discharged into a hopper, from which it is drawn into cars and spread on the cooling floor.

To cool the ore it is spread out thinly on the floor and furrowed. When the

surface has partially cooled, water is sprinkled over it, and the whole is raked over again. When sufficiently cool it is sent to an elevator that discharges it into the hoppers over the chlorination barrels. These hoppers are made of No. 14 sheet-iron, and have a capacity of between five and six tons each.

The chlorinating barrels, of which there are two, each having a capacity of 5 tons per charge, or 35 to 40 tons per 24 hours, are shells of tank steel ½ in. thick, 9 ft. long, and 5 ft. in diameter inside; the heads are of cast-iron inserted into the ends of the shell and bolted through flange and shell. They are 2½ in. thick and heavily ribbed; the trunnions, which are a part of the head, are 12 in. diameter and 12 in. long where the bearing comes, and 14 in. diameter and 4½ in. long inside the bearing, making a total length of 16½ in., and are bored to fit a 3-in. bolt, which passes through them and the entire length of the barrel. Each barrel has two charging-holes, 11×16 in., oval in shape. The covers are cast-iron, and when in place are held down by two heavy yokes and four 1½-in. bolts. An eye bolt is screwed in the center of each cover to lift it off with, and for this purpose a swinging lever is used, which holds it out of the way while the barrel is being charged.

The barrels are lined with lead, that on the heads being ½ in. thick, or 24 lbs. to the sq. ft., while the shell and other parts exposed to the gas or solution are covered with ⅜ in. thick, or 18 lbs. per sq. ft. The steel shell is made in one sheet with butt joint and cover plate, and all the rivet heads are countersunk, so that the inside is perfectly smooth. The lead lining is bolted in with flat-headed, lead-covered bolts. This prevents any solution getting between the lining and the shell.

The barrel is driven with a spur gear, encircling the shell, from a pinion and friction wheel, which can be thrown in or out of gear easily; a brake is also arranged so that the barrel can be stopped at any point in its revolution.

The supporting diaphragm for the filter is placed so that it will assume a horizontal position when the charging-holes are in position for charging. This diaphragm has an area of nearly 30 sq. ft., being 8 ft. 2 in. long by 3 ft. 8 in. wide. It is put in the barrel in the following manner: Two strips of wood 2½ in. thick on one edge and 1½ in. on the other, 6 in. wide, and the length of the barrel inside, are bolted to the shell through holes left for that purpose. Below these strips is built a lining of wood in staves 1½ in. thick and 5 in. wide, on which are placed the supporting segments, 3 in. thick. One is placed against each head and five others spaced equidistant between, which brings them nearly 13 in. apart. On top of the segments are laid the corrugated plates, lengthwise with the barrel. These plates are of wood 2 in. thick, four of which in width form the filtering surface. Each plate is corrugated lengthwise with grooves $\frac{5}{16}$ in. wide, ⅜ in. deep, and ⅜ in. between each groove; while ⅜-in. holes are bored through the plate three inches from either edge, and every five on the length cross grooves are cut to intersect these holes.

On the plates is spread the filter, which is a cloth of asbestos fiber woven a little finer than the ordinary gunny sack. Over this is placed an open grating of 1 in. ×1½ in. wood with openings 3½×9 in. This grating and the whole filter are held in place by five heavy brace pieces 3 in. thick, the ends of which slip under the wooden strips bolted to the shell; small spacing-pieces are placed between the

braces, which prevent their coming out or shifting out of place while the barrel is revolving.

All the woodwork that goes inside the barrel is previously boiled in tar and asphalt until saturated. This efficiently protects it from absorbing any solution and lengthens its life.

Below the filter at each end of the barrel are the valves through which the solution is drawn to the slime filters or the storage tanks. Above the filter and between the charging-holes and the ends of the shell are the valves and connections through which the wash water is pumped for leaching.

To one side below the barrel is placed a large storage tank, built of plank and timber and lined with six-pound lead, in the bottom of which is an ordinary quartz filter.

Directly below the solution valves are the slime filters, a heavy two-inch acid-proof hose with special connections connecting them with the solution valves. These filters are simply cast-iron cylinders flanged on each end, 30 in. in diameter by 18 in. long, with cast-iron covers, having inlet and outlet pipes bolted on. The cylinders are lined with eight-pound lead, and have filters similar to those in the barrel, except that above the asbestos cloth a quantity of quartz sand of different degrees of fineness is spread to a depth of 6 in., and on top of this is put a second asbestos cloth arranged to be lifted out and washed when the fine slime and sand has accumulated to such an extent as to retard filtration.

In front of the slime filters are the precipitating tanks, two for each barrel. They are placed so that the top of the tank is a little below the outlet of the filter. They are 6 ft. 6 in. in diameter by 10 ft. 6 in. high, of $\frac{3}{8}$-in. tank steel, with heavy cast-iron flange and cover on top end, and at bottom a $\frac{3}{4}$-in. circular flanged plate, flanged and riveted on the outside of shell, all rivets being countersunk so as to present a smooth surface for the lead lining to rest against. A 3-in. bolt passes through the center of the cover and the bottom and a casting placed as a large washer there. The cover has a manhole and three 2-in. holes, from two of which lead pipes extend near to the bottom of the tank. The tank is lined throughout with lead eight pounds to the foot. There is a 2-in. hole 9 in. from the center of the bottom plate, and another 2-in. hole on the side just above the top edge of the flange of the bottom plate. The tanks are supported in position on four heavy iron brackets riveted to the shell about four feet above the bottom, which rest on a timber frame, bringing the bottom of the tank about 4 ft. 6 in. above the floor. Between each set of tanks is placed a filter press with 12 chambers 19 in. square $\frac{3}{4}$-in. distant frames. The press has a filtering area of 57 sq. ft. Two heavy lead pipes from each tank, one from the hole in the bottom, the other from the hole in the side, lead to the press, and each pipe has an acid-proof valve close to the tank.

The gas generators in which the gas for precipitating is generated are placed on the floor at the top of the precipitating tanks. They are plain cast-iron cylinders of the same size as the slime filters. The one for generating the sulphur di-oxide is not lined, but has a cast-iron tray and deflecting plate. The other, for generating the hydrogen sulphide, consists of two cylinders, one above the other, with a plate having a 3-in. hole in the center between them. The cover of the upper cylinder has a hand hole 8 in. in diameter in the center, and a 2-in. hole near one

side. The lower cylinder cover has a $2\frac{1}{2}$-in. hole in the center and a small hole tapped for 1-in. pipe near the top on the side. Both cylinders and covers are lined with lead inside, and a $2\frac{1}{2}$-in. lead pipe is put in the 3-in. hole in the cast plate that separates the two cylinders. One end is burned to the lead lining on each side of the plate, and the other reaches to within $1\frac{1}{2}$ in. of the bottom of the lower cylinder.

The method of operation in the chlorination department is as follows: The ore from the cooling floor is elevated to the hoppers over the barrels and from there is charged into the barrel, in which the requisite quantity of water and the sulphuric acid for the charge have previously been put. After the ore chloride of lime is added and the cover put on and screwed down tightly. The friction gear is engaged and the barrel allowed to revolve for $1\frac{1}{2}$ to 2 hours, at the end of which time it is stopped, with the charging holes up so that the filter is horizontal. The connections are then made from the pressure pump to the barrel, with the slime filter and precipitating tanks. The pump is started and water forced into the barrel. The pressure is seldom raised above 40 lbs. per sq. in. The fresh water entering absorbs any free chlorine gas left in the barrel after chlorination, and the gold solution is delivered quite clear into the precipitating tank. Each precipitating tank has a capacity for the solution from two charges. The storage tank under the barrels is used in the event of getting more solution than will fill the precipitating tank, and when the filter cloth wears out and lets the sand through, the solution that accumulates here is afterward drawn into the precipitating tank and the gold precipitated.

After leaching the charge in the barrel, it is emptied into a tank below the slime filter floor and thence sluiced to the tailing dump.

The asbestos filter cloth is washed, to free it from any sand that may clog the interstices of the cloth, by directing a stream of water under pressure through a small nozzle against every part of it; the water thus put in is discharged by revolving the barrel, which also washes out any tailings that still remain. The life of a filter cloth is between 50 and 60 charges.

As soon as the precipitating tank is full of solution, the sulphurous acid gas generator is started and the gas forced through one of the pipes leading to the bottom of the tank. The gas is generated from brimstone burned on a tray in the generator with a current of air forced in at the bottom and deflected over the surface of the burning mass. The excess of air carries the gas through the pipe into the solution, in which it is rapidly absorbed, the air acting as a stirrer. When sufficient gas has been passed into the solution to convert all the free chlorine into hydrochloric acid, the hydrogen sulphide gas is turned in and the gold precipitated as sulphide. The hydrogen sulphide gas is generated from iron sulphide and dilute sulphuric acid, the acid solution being poured into the lower cylinder of the generator and the iron sulphide on a perforated lead plate close to the bottom of the upper; air pressure is turned into the lower cylinder through the hole in the side, driving the acid solution up through the $2\frac{1}{2}$ in. lead pipe into the upper cylinder, where it comes in contact with the iron sulphide. The air is also allowed to pass through the generator to the bottom of the precipitating tank, where it acts as a stirrer and collects the precipitated sulphide into a flocculent form. As soon as the precipitation is complete the air is shut

off and allowed to escape from the lower cylinder, when the acid solution recedes from the iron sulphide and the gas ceases generating. The acid solution is used over again until saturated with iron sulphate.

The tank precipitated is allowed to stand for about one hour, in which time the more part of the gold sulphide has settled to the bottom. The valve on the pipe leading to the filter press from the side of the tank is then opened and the supernatant liquor allowed to pass through the press, in which any sulphide still in suspension is collected. When filtration becomes slow, air pressure is turned into the tank and the liquor is forced through the press. After four precipitations, the precipitate that has collected in the bottom of the tank is forced into the press through the pipe in the bottom of the tank.

To compress the sulphide cake in the press, air is allowed to blow through until the filtrate stops coming. The press is then opened and the sulphide cake removed, dried and roasted, and put away until the clean-up is made, when the accumulation from fifteen days' run is put in a crucible with borax, niter, and a little quartz sand, fused and cast in a mold.

The amount of precipitants used to precipitate a tank of 2500 gallons of solution are: Sulphur 2 lbs., iron sulphide 4 to 5 lbs., sulphuric acid 16 lbs., and 9 gallons of water. The capacity of the works is 75 tons per day. The power to drive the whole plant is furnished by a 125 horse-power engine and two 75 horse-power stationary tubular boilers, which are largely in excess of the amount required. A small air compressor and a steam-pump take steam from the boilers. The number of men needed to operate the plant is 30, including the chemist and superintendent. For power 6 to 7 cords of wood, or 4 tons of bituminous coal, are required; for roasting, 5 to 6 cords of wood per day are used. The chemicals required are: Chloride of lime, 8 lbs. per ton chlorinated; sulphuric acid, 15 lbs. The wear and tear of plant, oil, etc., are estimated as between 25c. and 30c. per ton of ore treated.

The buildings to cover the plant are: Coarse crusher and dryer (on side-hill), 34×38 in.; mill, 34 foot-posts, 38×40 in.; roaster, 40×62 in.; chlorination, 36×54 in.; engine and boilers, 46×40 in. Space is allowed for one more set of rolls, a second roasting cylinder, and two extra barrels, which will nearly double the capacity of the plant. Several plants are at present operating this process successfully and economically. The Golden Reward, South Dakota, the pioneer works of the kind, has paid $60,000 in dividends during the past year, and is now treating between 90 and 100 tons of ore per day through four barrels.

The Cyanide Process.

By Louis Janin, Jr.

It is difficult to find a period in the history of chemistry since the radical cyanogen was discovered in which the solvent power of potassium cyanide on gold has not been mentioned. Hagen as early as 1805 (*Untersuchungen,* vol. i. p. 665) states that gold is dissolved not only by free chlorine and aqua regia, but by a potassium-cyanide solution. Gmelin says, probably quoting from Elssner's researches, that cadmium, silver, and gold are dissolved by potassium cyanide in the presence of air. Glassford and Napier were also aware that cyanide of potassium dissolved gold, and published the fact in 1844 (*Phil. Mag.,* vol. xxv. p. 64). In the French edition of Thompson's Chemistry, published in 1807, and in Proust's paper on "Facts for the History of Prussiates" (*Annales de Chimie et de Physique,* 1806, vol. lx. pp. 225–249), the prussiate of potash is stated to be a solvent of gold.

Elkington in 1840 (see English Patent Specification No. 8447 for that year) was, however, the first to make practical use of this reaction in his galvano-plastic operations. He dissolved either oxide of gold, or metallic gold in a state of fine division, in a 20% solution of potassium cyanide. Faraday, in the *Transactions of the Philosophical Society for* 1857, describes an experiment made in 1856, in which he used a dilute solution of cyanide of potassium for dissolving gold.

As to the practical application of this process to the reduction of ores, it is found that United States Letters Patent No. 61,866, dated Feb. 5, 1867, were issued to Julio H. Rae of Syracuse, N. Y., for the treatment of auriferous and argentiferous ores by potassium cyanide. In brief, Rae's method consisted in treating the ores with a solution of potassium cyanide, aided by the electric current, and in a subsequent electrolytic precipitation of the metals from the cyanide solution. Even at that date this use of potassium cyanide was not considered new. Patents for the use of potassium cyanide in metallurgical operations were also issued to Clark (No. 229,586) in 1880, and to Faucett (No. 236,424) in 1881. John F. Sanders of Ogden, Utah, received patent No. 244,080, dated July 12, 1881, for a composition consisting mainly of potassium cyanide for dissolving the coating from the gold of the so-called coated gold ores preliminary to pan-amalgamation. In this method he unknowingly dissolved the gold as well as the coating, and reprecipitated it by the aid of the iron of the amalgamating pan and the mercury employed. Although these patents show the antiquity of the process, that of Rae in particular covering any claim to the use of potassium cyanide as a solvent of gold as found in ores, none was pushed to any practical success. Like a thousand other patents, they were suffered to slumber, without any pronounced effort being made to introduce any of them into the field of metallurgy.

At length an inventor, Jerome W. Simpson of Newark, N. J., came, who had studied more thoroughly the details of metallurgical processes, and with a clearer idea of what was needed, he secured a patent, which, if untenable, was at least more comprehensive, more clearly worded, and more successful when introduced

into practice than any which had preceded it. Simpson's patent (No. 323,222) was issued July 28, 1885, and in his specifications he says:

"To carry my invention into effect, I first grind or crush the ore containing the metal to be extracted to a powder of more or less fineness. This powder is then treated with certain salts in solution adapted to combine chemically with the metal in said ore and form therewith a soluble salt. After thorough agitation, to mix the solution with the ore, the mixture is allowed to stand until the solid matter is settled and the solution has become clear. I then suspend a piece or plate of zinc therein, which causes the metal dissolved in the salt solution to be precipitated thereon, from which it can be removed by scraping or by dissolving the zinc in sulphuric or hydrochloric acid. The precipitated metal may then be melted into a button. The salt solution I use for dissolving the metal from the ore is composed of one pound of cyanide of potassium, one ounce carbonate of ammonia, one half ounce chloride of sodium, and sixteen quarts of water, or other quantities in about the same proportions. This solution is particularly adapted for ores containing gold, silver, and copper in the form of sulphurets. For an ore containing gold and copper only I use cyanide of potassium and carbonate of ammonia about in the proportions named. For ores rich in silver I employ a proportionately larger quantity of chloride of sodium.

"I am aware that cyanide of potassium, when used in connection with an electric current, has been used for dissolving metals, and also that zinc has been employed as a precipitant, and the use of these I do not wish to be understood as claiming, broadly. I am also aware that carbonate of ammonia has been employed for dissolving such metals as are soluble in a solution thereof, and the use of this I do not claim. But what I claim as new is:

"1. The process of separating gold and silver from their ores, which consists in subjecting the ore to the action of a solution of cyanide of potassium and carbonate of ammonia, and subsequently precipitating the dissolved metal, substantially as set forth.

"2. The process of separating metals from their ores, to wit: subjecting the ore to the action of a solution of cyanide of potassium, carbonate of ammonia, and chloride of sodium, and subsequently precipitating the dissolved metals."

While Simpson added sodium chloride to his solution, undoubtedly for the purpose of chloridizing a portion of the silver, the use of ammonium carbonate is somewhat hard to understand. It will be observed that Simpson distinctly states that he does not claim the use of zinc as a precipitant, and admits its prior use. He admits also that his claim for the use of potassium cyanide as a solvent is extremely weak, and relies mainly upon the combination in solution of the several chemicals.

A caveat in the names of F. M. Endlich and N. H. Mühlenberg, covering the use of potassium cyanide for the extraction of silver and gold from their ores, was filed in the spring of 1885, but a patent was not secured, and the matter is still pending.

In 1885 I made a series of experiments in San Francisco with potassium cyanide, and in 1886, when in Utah, another series, the results of which were published in the *Engineering and Mining Journal* for Dec. 29, 1888. I filed a caveat on May 1, 1886, but this also was not pushed to the taking out of a patent, although my results were good with both gold and silver ores.

I have thus followed the history of potassium cyanide as a solvent for gold up to the period of Messrs. MacArthur and Forrest's experiments in Glasgow, which are said to have occupied over three years before and after the issue of their English patent (No. 14,174) on Oct. 19, 1887. After patenting their process in England—the particulars of which will be described later on—they applied for patents in nearly every other country which contains gold and issues patents. Their application for an American patent was dated in November, 1887, but their claims were so badly worded and so ridiculously comprehensive, and their discoveries withal so ancient, that, after numerous emendations and modifications of their claims, their patent (No. 403,302) was not granted until May 14, 1889,

when their claims were limited to the use of a dilute solution of potassium cyanide, described as follows:

"The invention consists in subjecting the auriferous or argentiferous ores to the action of a solution containing a small quantity of cyanide, as hereinafter set forth, without any other chemically active agent, such quantity of cyanide being reckoned according to its cyanogen, and the cyanogen being proportioned to the quantity of gold or silver, or gold and silver, estimated by assay or otherwise to be in the ores under treatment. By treating the ores with the dilute and simple solution of a cyanide, the gold or silver is, or the gold and silver are, obtained in solution, while any base metals in the ores are left undissolved, except to a practically inappreciable extent; whereas when a cyanide is used in combination with an electric current or in conjunction with another chemically active agent,—such as carbonate of ammonium, or chloride of sodium, or phosphoric acid,—or when the solution contains too much cyanide, not only is there a greater expenditure of chemicals in the first instance, but the base metals are dissolved to a large extent along with the gold or silver, and for their subsequent separation involve extra expense, which is saved by our process.

"In carrying out our invention practically, we take the ore in a powdered state and mix with it the solution of cyanide in a vessel made of or lined with any material not appreciably acted on by the solution. . . . We regulate the quantity of cyanide so that its cyanogen will be in proportion to the quantity of gold or silver in the charge of ore; but in all cases we dissolve it in sufficient water to keep the solution extremely dilute, because it is when the solution is dilute that it has a selective action such as to dissolve the gold or silver in preference to the baser metals.

"In dealing with ores containing 20 ounces or less of gold or silver, or gold and silver, per ton, we find it most advantageous to use a quantity of cyanide the cyanogen of which is equal in weight to from 1 to 4 parts for every 1000 parts of the ore, and we dissolve the cyanide in a quantity of water of about half the weight of the ore. In the case of richer ores, while increasing the quantity of cyanide to suit the greater quantity of gold or silver, we also increase the quantity of water so as to keep the solution dilute. In other words, the cyanide solution should contain from 2 to 8 parts, by weight, of cyanogen to 1000 parts of water, and the quantity of the solution used should be determined by the richness of the ore. After the solution has been decanted or separated from the undissolved residues, the gold and silver may be obtained from it in any convenient way, such as evaporating the solution to dryness and fusing the resulting saline residue, or by treating the solution with sodium amalgam.

"Having fully described our invention, what we desire to claim and secure by letters patent is:

"The process of separating precious metal from ore containing base metal, which process consists in subjecting the powdered ore to the action of a cyanide solution containing cyanogen in the proportion not exceeding 8 parts of cyanogen to 1000 parts of water."

Some time after this patent was issued, patents covering the use of zinc, preferably filiform, or thread-like, for a precipitating agent, and the use of caustic alkalies for neutralizing ores containing acids, or acid salts, were granted to Messrs. MacArthur and Forrest. It may be seen, therefore, that their patents cover substantially three points: the use of dilute solutions of cyanide (not more than 8 parts of cyanogen to 1000 of water); the use of zinc, preferably filiform, as a precipitate; and the employment of caustic alkalies for neutralizing an acid ore. As shown in this record, these several claims were antedated by other inventors, and are not now patentable. For years zinc had been used by electroplaters for recovering gold or silver from cyanide solutions; and on April 29, 1884, an English patent (No. 5125) was issued to Astley Paston Price of London for certain improvements in the extraction of the precious metals from their ores, covering the use of zinc as a precipitating agent. His method of extraction, upon which he himself laid little stress, has no bearing on the case, but the manner of precipitation is of consequence. I quote Price's claims as follows:

"I wish it to be distinctly understood that I do not claim as any part of my invention the methods or processes for effecting the solution of the gold or of the silver, when contained in ores or metallurgical compounds or products; but what I do claim is effecting the precipitation of the precious metals, *videlicet* of gold or of silver, or of gold and silver, resulting from the treatment substantially as hereinbefore mentioned, or otherwise of ores or metallurgical products such as or similar to those hereinbefore referred to, by the employment when in a fine state of division of zinc, or of other metal or metals other than copper which are capable of precipitating gold or silver, the same being brought into contact with the solution."

The use of caustic alkalies as neutralizing agents is almost as old as the art of metallurgy itself, and if it has not been patented before it is not because it has not

been known, but because few metallurgists are willing to claim as their invention what is known to the whole profession. It has been, however, made the basis of a prior and untenable patent by E. H. Russell, for use in hyposulphite lixiviation. The narrow claim for the use of solution containing not more than 8 parts of cyanogen (20 parts of chemically pure potassium cyanide and 30 parts of commercial cyanide) to 1000 parts of water is no better than Simpson's worthless claim for a solution of definite proportions containing 25 parts of cyanide to 1000 parts of water.

In the writer's opinion, Messrs. MacArthur and Forrest have no claims whatever upon those who wish to use the process, further than gratitude for having revived an old process and placed it in operation. In South Africa, favored by ores extremely well adapted to the process and by admirable business management, they have made an enviable technical and financial success, due credit for which must be given them.

EXPERIMENTS ON SILVER ORES WITH CYANIDE SOLUTION.

In preparing the accompanying table I have recognized the fact that laboratory tests, particularly in wet processes, where excesses of chemicals are usually employed, are often misleading. The list given contains, however, nearly every variety of argentiferous and auriferous mineral found in our mining camps, and the results indicate in a measure those that may be expected from similar ores, and allow us to draw interesting deductions as to the applicability of the cyanide process to various types of ore.

RESULTS OF EXPERIMENTS MADE ON TYPICAL SILVER ORES WITH POTASSIUM CYANIDE, COMPARED WITH OTHER METHODS OF EXTRACTION.

Name of Mine.	Value of Ore, Oz. per Ton.	Percentage Extracted by Lixiviation with:				
		Caustic Ammonia.	Concentrated Brine.	Hyposulphite of Soda.	Russell Process.	Cyanide of Potassium.
Grand Central, Arizona	43.2	48.2	50.5	86.6	93.7	92.6
Silver Reef, Utah	45.0	20.0	36.9	50.7	77.8	82.8
Horn Silver, Utah	184.0	56.6	74.2	81.6	90.7	93.6
Tybo, Nevada	20.0	....	8.0	30.0	58.0	71.8
Sombretillo, Mexico	80.4	6.7	3.4	75.1	84.0	97.3
Ramshorn, Idaho	89.6	2.2	11.8	34.4	50.5	80.0
Broken Hill, N. S. W.	24.8	67.0	....	84.3	97.0	99.7
Broken Hill, N. S. W.	34.0	12.8	....	43.2	57.0	84.6
Bullionville, Nevada	10.0	....	....	....	35.0	32.0
Bertrand & Geddes, Nevada	176.4	....	....	...	11.1	11.8
Argenta, Montana	75.2	....	....	....	12.2	5.7
Belmont, Nevada	20.0	....	....	....	20.0	35.0
Belmont, Nevada	510.8	....	....	....	37.2	47.5
Las Yedras, Mexico	130.0	....	....	....	4.6	41.5
Ontario, Utah	80.8	....	....	....	44.0	72.5
Daly, Utah	74.0	....	....	....	17.0	81.1
Albert Silver Mine, South Africa	[illegible]	....	....	....	....	None

The general characteristics of the various ores tested are, briefly, as follows:

Sample No. 1 is typical of the upper level ores of the Grand Central mine, one of the Tombstone (Arizona) group. The ores of these mines, although largely silicious, contain considerable quantities of lime and manganese. The silver minerals are principally cerargyrite and argentite. These have been considered typical free-milling ores, although it is doubtful if over 84% has been recovered by raw pan-amalgamation, and at times the percentage has fallen appreciably below

this. Poor results were locally ascribed to the presence in increased quantities of molybdate of lead or manganese dioxide.

The silver in Sample No. 2, from the Christy mine, Silver Reef, Utah, is found as chloride, sulphide (in smaller quantities), and metallic silver, in a gangue of sandstone, somewhat discolored by carbonate of copper. These ores are worked by the free-milling, pan-amalgamation process, yielding at the Christy, Leeds, and Stormont mills about 75% of their value. The Russell process was also tried, but owing to the increasing percentage of metallic silver, comparatively insoluble in the cuprous hyposulphite solution, it had to be abandoned. In none of the experiments made by me on this class of ore was the extraction by cyanide of potassium less than 80%.

The Horn Silver ore (Sample No. 3) contains, like all the surface ores of that mine, large quantities of chloride of silver readily soluble in cyanide solution, or indeed in any of the other solutions tried. This particular sample contains but little lead, and that in the form of cerusite.

The ores of Tybo, Nev., are among the most difficult of Western ores to treat, even after roasting, during which they suffer a severe loss, only about 85% of the value of the roasted pulp being recovered. The mineral is principally a complex sulphide and fahlore, so that the extraction of 71.8% is a remarkably good result.

The Sombretillo ore (Sample No. 5) is principally, if not entirely, chloride of silver, the gangue being silicious. The phenomenally good results obtained with this ore, as shown in the table, are therefore not to be wondered at.

The Ramshorn ore (Sample No. 6) contains both galena and carbonate of lead, the silver being associated mainly with the lead mineral, although some is contained in the accompanying pyrite and zinc blende.

Sample No. 7 is the rich kaolin ore from the Broken Hill deposits in the Barrier Range, New South Wales. The occurrence of silver in this ore is peculiar. It is in the form of embolite, or chloro-bromide of silver, disseminated throughout the whitish mass, and concentrated on the surface of the quartz and garnet crystals which it contains. These crystals are proportionately richer than the surrounding mass. I tested this ore in vain for iodine, although on the authority of C. A. Luckhardt it is present. This is, of course, a typical free-milling ore, 95% of its value being extracted by amalgamation.

Sample No. 8, while of a different quality, is from the same mine. It is a silicious iron ore carrying some 38% Fe O. The results obtained with it, although good, were not so satisfactory as with the preceding sample.

The Bullionville tailings (Sample No. 9) are the result of several workings, having been amalgamated at least twice and partially concentrated. They contain 10% of carbonate of lead, some galena, and considerable iron in a silicious gangue. Tests by amalgamation and lixiviation gave poor results, and by the cyanide solution still poorer were obtained. It is reported that certain tailings at Bullionville, upon being tested by cyanide solution, yielded 10 oz. of silver and 90% of the gold. As the average grade is about 12 oz. of silver and \$2 of gold, these results are doubtful.

The Bertrand & Geddes ore (Sample No. 10) contains antimoniate of lead, with which the silver was combined. As amalgamation gives poor results, the pro-

cess adopted is to chloridize the ore in Bruckner cylinders and leach by hyposulphite of soda or lime. This method extracts about 84% of its value.

The Argenta ore (Sample No. 11), from Beaverhead County, Mont., contains over 40% lead, and is unworkable by any process except smelting.

The Belmont ores (Samples No. 12 and 13) contain arsenical pyrites, pyrite, blende, and galena, with the silver in fahlore and arsenical and antimonial ruby forms. They are worked by the usual chloridizing roasting and amalgamation process, although recently, I understand, a lixiviation plant has been erected.

The Las Yedras ore (Sample No. 14) contains large quantities of carbonate of lime, with the silver in the form of ruby silver and arsenical pyrites. The ore is worked by chloridizing roasting and subsequent lixiviation with hyposulphite of soda.

The Ontario and Daly ores (Samples 15 and 16) contain the silver principally in in the form of fahlore, more or less decomposed. The following are analyses:

	Ontario.	Daly.
Silica	75.0	76.60
Zinc	5.73	5.30
Lead	1.80	3.50
Iron	2.80	1.65
Sulphur	2.23	0.70
Lime (CaO)	1.76	1.32
Magnesia (MgO)	0.23	trace
Copper	0.29	0.39
Silver (oz.)	39.50	39.10
Gold (oz.)	0.044 ($0.91)	0.044 ($0.91)

They give excellent results by amalgamation or lixiviation after a chloridizing roast.

Sample No. 17 was tested by Mr. Bettels of the Robinson Gold Mining Company, South Africa. It contained 10% of copper, which interfered with the extraction of the silver, which was in the form of a sulphide.

I have tested ores containing varying percentages of copper, but thus far have not met with so pronounced a difficulty, although it is easy to imagine that should the energy of the cyanide be neutralized by dissolving more soluble minerals, the extraction of the silver or gold must suffer.

Conclusions and Deductions.—The conclusions and deductions to be derived from a study of the foregoing are, that silver in oxidized surface ores, or where it occurs as a chloride, is readily attacked by cyanide of potassium, and that where no minerals are present which exert an unfavorable influence this method may prove economical. It must be confessed, however, that even with these conditions it has but a limited range of usefulness. On the other hand, where lead, oxide of copper, or certain oxides of iron occur, the results are so poor as to preclude the use of the process.

The results obtained from different samples of silver ore from the same mine vary greatly, for a slight increase of an undesirable element, which would not affect amalgamation in the slightest degree, causes a great decrease in the percentage of extraction by cyanide. The following results obtained from the raw ore of the Daly mine at different dates, between which the variation in its constituents was but trifling, illustrates this:

	Extracted.		Extracted.		Extracted.
April 10	81.6%	April 14	77.6%	April 18	65.5%
" 11	78.0%	" 15	79.7%	" 19	66.9%
" 12	81.7%	" 16	75.2%	" 20	69.0%
" 13	77.6%	" 17	73.4%	" 22	73.0%

Here we have a variation between extremes during 13 days of 16.2% with potassium cyanide, while with amalgamation there was a variation of but 2%.

In the foregoing the question of treating argentiferous ores after roasting has not been considered, as it is at once evident that such an expensive reagent as potassium cyanide, easily and quickly decomposed by the many acid salts formed in a chloridizing roasting, could not replace any of the several economical methods now in use.

RESULTS OF EXPERIMENTS MADE WITH POTASSIUM CYANIDE ON GOLD AND SILVER ORES FROM DIFFERENT MINES.

Name of Mine.	Assay Value.		Per Cent of Value Extracted.		Name of Mine.	Assay Value.		Per Cent of Value Extracted.	
	Gold, Oz. per Ton.	Silver, Oz. per Ton.	Gold.	Silver		Gold, Oz. per Ton.	Silver, Oz. per Ton.	Gold.	Silver
Gregory, Colo..........	0.800	1.4	90.0	3.0	Minas Prietas, Mex........	0.277	9.7	85.6	30.4
De Lamar, Idaho.......	1.000	26.0	90.0	83.0	Atlanta, Idaho	0.600	5.2	63.4	78.6
Revenue, Mont.	1.350	4.0	94.0	52.0	Con. Cal. & Virginia, Nev.	2.260	108.6	38.8	49.8
Southern Cross, Mont.	1.220	0.7	93.0	50.0	Paradise Valley, Nev	0.090	49.2	77.8	25.8
Chollar Potosi, Nev....	0.130	2.6	76.2	70.4	Custer Co., S. Dakota.....	1.950	....	21.0	....

The experiments on the Gregory concentrates, which consist of pyrite, some arsenopyrite and chalcopyrite, with traces of galena and blende, were made by the Gold and Silver Extraction Company, of Denver, Col. These pyrites are usually bought by the Boston and Colorado Smelting Company, which treats them, when mixed with other ores, by matte fusion, modified Ziervogel process for the extraction of the silver, and a process of its own for the treatment of the rich auriferous bottoms.

The De Lamar ore consists of a silicious and limestone gangue, impregnated with silver sulphides and chlorides and iron pyrites. Some of the gold is free, but the greater part is in combination. The ores at present are treated by raw pan-amalgamation, which saves from 83% to 85% of the contents, and is considered satisfactory. A considerable quantity of this ore has been treated by the cyanide process, with flattering results.

The ores from the Revenue mine, Madison County, Mont., have puzzled metallurgists for many years. They are oxidized surface ores, containing a considerable quantity of iron. When the mine was bonded to George D. Roberts of New York considerable attention was paid to the treatment of the ore by the late E. N. Riotte, who, after making various experiments, tried cyanide. His results were far from satisfactory, although it is now stated by Mr. Turner, the manager of the property, that they are extracting by the same process of cyanide some 85%. It is also stated that 70% of the contents of tailings from amalgamation has been extracted, at a cost per ton for extraction of $5, but as the ore is one which would naturally cause a considerable consumption of cyanide, this statement seems doubtful.

The Southern Cross mine of Deer Lodge County, Mont., has ores which contain from 42% to 50% of iron in the form of limonite, evidently the result of the decomposition of pyrite. The ores have been treated in a 10-stamp gold mill with amalgamated silver plates and with copper plates, but without extracting over 40%.

The gold is so fine that a speck can rarely be seen on panning large samples. The ore assays from $10 to $40 per ton in gold, with but a trace of silver, and its average value may be taken at $15 per ton. In 1890 I made a number of experiments on the ore by the cyanide process, with good results so far as extraction went. I also made experiments by the chlorination process applied to raw ore. These were the first successful experiments by this process, so far as I have been able to learn, applied directly to ores without undergoing a previous treatment. When leached by cyanide as much as 93% was extracted, the results on high grade ore varying from that figure to 85%. It was observed on treating in a rotating barrel that while in a short time a large percentage of the gold was extracted, the quantity gradually decreased as the time lengthened, so that the results after a number of hours showed an extraction of only 25%. This indicates that the ore either exerts a decomposing action on the solution or else reprecipitation occurs. It has been stated that experiments made recently on a large scale have proved successful, but in any event the consumption of cyanide would be large, and would increase with the extraction of less decomposed ore. Chlorination yielded on an average some 90%, with a consumption of 10 lbs. of bleaching-powder and 15 lbs. of sulphuric acid to the ton. The total expense of treatment by this method would probably fall below $4 per ton if a sufficient quantity of ore were treated. The cyanide process, owing to the decomposition of the solution, would cost over $5 a ton.

The Chollar Potosi ores have been considered the most rebellious of the Comstock ores, not over 75% on an average being saved by pan-amalgamation. From the tailings, however, cyanide extracts some 76% of the gold, and it is probable that the portion previously extracted by amalgamation would be extracted also, which would make a total extraction of 90% by cyanide. The Consolidated California-Virginia ore contains metallic gold and silver and comparatively rebellious sulphides, such as tetrahedrite, stephanite, and sternbergite. The results, therefore, on both metals were low, but it is probable that the ordinary type of Comstock ore will yield far better results. Nevertheless, considering the perfection which pan-amalgamation has reached, it is extremely doubtful if the cyanide process will ever be introduced under the present management.

The ore of the Minas Prietas mine of Sonora, Mexico, consists of quartz, with oxides of iron and manganese, and hardly a trace of sulphur. Some of the gold is free, but the silver is more or less rebellious. The following results of monthly runs of the 40-stamp Boss process continuous mill are of considerable interest, as these tailings, amounting to nearly 100,000 tons, are now to be treated by the cyanide process.

Value of Ore per Ton.		Value of Tailings per Ton.		Per Cent Extracted.		Value of Ore per Ton.		Value of Tailings per Ton.		Per Cent Extracted.	
Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
$16.15	$14.13	$3.46	$13.18	78.5	9.2	$18.99	$17.53	$4.65	$16.05	75.4	9.2
14.54	13.46	3.47	12.17	76.1	9.2	18.16	16.97	4.05	15.73	77.6	9.2
18.67	15.26	4.87	13.96	70.9	9.2	17.42	17.08	4.52	15.88	74.1	9.2
19.72	17.93	5.08	15.82	74.1	9.2	17.19	19.02	3.91	18.41	77.2	9.2

The higher-grade tailings have been worked with much success by the amalgamation process invented by Alexis Janin, but the low-grade tailings are left for

the cyanide process. With this the extraction of gold will undoubtedly be very fair and the consumption of cyanide low, while the silver will still remain rebellious. Considering the small contents of precious metals, it is doubtful if the process will prove a financial success.

The Atlanta ores were extremely rebellious. They were treated while the mine was in operation by roasting in a Bruckner furnace and were then amalgamated. The percentage extracted, however, was low, not running above 80% on the average, and with a heavy loss of gold in the furnace. The extraction by cyanide, all things considered, was quite fair, especially with the free surface ores. Samples of tailings yielded nearly 80% of the gold and 60% of the silver contained.

The Paradise Valley ores are extremely good for experimental purposes, as they consist of a clean quartz gangue with the mineral in the form of proustite and pyrargyrite distributed throughout it, so that the solutions employed act on the minerals alone, being entirely unaffected by the gangue. The results obtained in the extraction of gold by cyanide were fair, although there is but a small percentage in the ore and that contained in mispickel. It is said that attempts are now being made to treat the tailings from the old 20-stamp dry crushing and chloridizing mill by the cyanide process.

The Custer County, South Dakota, ore, which was tested by Mr. S. D. Porter, consisted of crystalline quartz with free gold, oxide of iron, and a small quantity of tellurium. By free milling 26% was extracted, and by concentrating 14.7 tons into one ton, a concentrate valued at $239.56 a ton was produced—a saving of 41% of the assay value. Further tests by concentrating 7.35 tons into one gave a concentrate valued at $165.36 a ton, a saving of 57%. Raw chlorination saved 84%. Other ore in the vicinity gave results as high as 92% by the cyanide process.

E. N. Riotte made a series of experiments on the Bald Mountain ores by the cyanide process, but the results were not successful. Tests at the Golden Reward Works, Deadwood, where they are now using the barrel chlorination process with great success, were failures according to the superintendent, Mr. Bamberger. Messrs. Frank and Darling have informed the writer that these experiments were successful so far as the extraction of the metals was concerned, but were failures mechanically owing to the leakage of the vats. They state that 94% of the gold was extracted and 87% of the silver, with a consumption of 0.9 lb. of cyanide per ton.

Conclusions and Deductions.—It would seem probable that, in ores containing both gold and silver, only the oxidized surface ores can be treated with success, both the silver and gold minerals from depth proving refractory. The Comstock ores should give fair results, as should those of the De Lamar mine, and the Minas Prietas ore should yield a high percentage of the gold but very little of the silver. With the majority of these ores the consumption of cyanide would be large, as many minerals other than those of silver are contained in them and would have a decomposing action upon the solution.

The interest which has been caused recently by the statement, substantiated by the fact, that cyanide of potassium dissolves the gold from auriferous pyrite and arsenopyrite, leaving the mineral to all appearances untouched and undecomposed, has reopened a much-discussed question, viz., "the condition of gold in pyrite." These results, it is true, do not fully answer this question, for if the gold were either a sulphide, as is claimed by some, or in the metallic state, the

cyanide solution would still dissolve it; but since the material operated upon is comparatively coarse, these results may give us some information as to whether the gold is in uniform mixture with the molecules of the pyrite or simply a superficial and local deposition.

Those who have held the theory of chemical combination of the gold, silver, and iron in a double sulphide of the metals—and they number among them many eminent men—have based their arguments, as a rule, upon the difficulty of amalgamating the gold in these minerals when undecomposed, and upon the ease with which they are treated when the sulphur is eliminated, leaving, according to their theory, and in apparent confirmation of it, the gold in the metallic state. As the artificial sulphide of gold is unstable and is quickly decomposed by heat, leaving metallic gold, they argue that the gold in pyrite must have been partly at least in the form of a sulphide.

Others have subjected auriferous ores in which they suspected the existence of auric sulphide to the action of alkaline sulphides, claiming that if gold went into solution it existed as a sulphide, but forgetting that metallic gold is soluble in alkaline sulphides to a marked degree. In reality those who believe in the occurrence of auric sulphide have relied chiefly for proof on the refusal of gold in pyrite to amalgamate readily, and this proof is open to many objections. The physical condition of the gangue, crushed pyrite in this case, might offer such difficulties as Malaguti and Durocher found with clay in the amalgamation of silver, or, as is found at the present time, in actual practice, in treating chloritic and argillaceous ores by amalgamation. Little is known of the chemical or mechanical effect of gangue minerals on the affinity of mercury for gold or silver. Again, the gold while metallic might have been in an allotropic state, analogous to that of silver found unamalgamable by M. Carey Lea. It might be coated by a film usually considered as iron oxide, but more probably caused by the evolution of sulphuretted hydrogen from the decomposition of pyrite or marcasite. In any event this failure to amalgamate might be charged to many causes other than the presence of auric sulphide.

Ott, Wurtz, Bergman, Blake, and others claim that metallic gold is disseminated mechanically through the mass of pyrite; but the action of cyanide of potassium and other chemicals on comparatively coarse material would seem to indicate that the interior of the crystals is not auriferous to any extent, and that therefore the deposition of the gold must be superficial. The enrichment of the pyrite must be confined to its crystalline faces, and possibly, but not probably, to its cleavage planes.

The crushing by rolls or stamps of ore through which pyrite is disseminated does not reduce all the crystals of that mineral to powder, but liberates a portion of them from the gangue practically whole. A microscopical examination of the pulp will show this. Yet from these crystals, when concentrated, cyanide of potassium frequently extracts experimentally over 90% of the gold, and barrel chlorination, as proved by John E. Rothwell in actual practice, extracts with or without the use of an oxidizing agent, such as nitre-cake, an almost equal percentage. Certainly these results could not have been obtained were the gold disseminated throughout the crystalline mass. In the Republic of Colombia the writer found crystals of pyrite in a porphyritic gangue, which had, in many cases,

gold in small globules on the surface and also one octahedral crystal of hematite, evidently a pseudomorph after pyrite, weighing 638.7 milligrammes and which had a globule of gold weighing 26.8 milligrammes on its surface. The crystal of hematite after the large piece of gold had been removed was shown to contain but 4.3 milligrammes of gold, and this, in all probability, was on the surface, in such small particles as to be invisible to the unaided eye.

Crystals of pyrite are not infrequently found adhering to an amalgamated copper plate. This is undoubtedly due to the amalgamation of the particles of gold on their surfaces.

The ores of the Southern Cross mine, Deer Lodge County, Mont., which consist of limonite from the alteration of pyrite, amalgamated to about 40%. In panning large samples but a color or two of gold could be seen, although the ores assayed at times as high as $40 to the ton. From this ore over 90% of the gold was extracted in experimental tests by the use of cyanide of potassium, and fully as good results were obtained by chlorination in a closed vessel with bleaching powder and sulphuric acid. Here the ore was thoroughly decomposed, but still the gold would not amalgamate to a much higher percentage than if it had existed with the original pyrite, while the chemicals took it immediately into solution. It will be seen that my main reasons for suspecting the gold to be deposited superficially and in the metallic state are derived from the actions of the several chemicals on unfractured pyrite, and the conclusions drawn from these results, while still somewhat hypothetical, are certainly more logical than those which have been evolved up to the present time. They may be summed up as follows:

1. The gold exists in pyrite as metallic gold, not as a sulphide. 2. In the majority of cases the gold is confined to the surface of the mineral and is not disseminated throughout the mass.

In connection with the foregoing, the following details of a microscopical examination by Professor Morton of the condition in which the pyrite was left after being leached with cyanide will prove interesting, as it confirms to a certain degree the theory advanced by the writer:

"Upon the ordinary auriferous sulphide of iron, or arsenical pyrites, the solution of potassium cyanide acts readily, not by dissolving the sulphuret but by attacking the gold upon its exposed edges and eating its way into the cubes by a slow advance, dissolving out the gold as it goes. An examination, with the microscope, of the pyrite after the gold has been removed suggests the method of the operation. A sample of very rich sulphurets from a mine north of Redding was treated with a weak solution, less than two tenths of 1%, for 168 hours; the assay showed a complete extraction of the gold; as the sulphurets showed no change in their appearance to the naked eye, some of them were placed under the microscope.

"There is no change visible in the form of the crystals as a whole; along the fractured faces the mispickel looks clean and unaltered, showing the silvery-white color and intense refraction of the arsenopyrite. Upon the faces of the crystals appear dark lines, short and parallel to each other. In places they are crowded close together; in other parts they are at considerable distances, but always in parallel lines. The lines vary in length, being from 4 or 5 times to over 100 times their width; the lines are very irregular and often broken. These lines are fissures in the pyrites and extend so deep into the pyrite that the microscope does not reveal their depth. By using the higher powers the walls of one of the fissures were seen to be completely honeycombed, looking somewhat like two empty honeycombs set opposite each other; evidently the mineral removed was crystallized along its contact walls at least. As the raw or untreated pyrite does not show any such fissuring, but, upon the contrary, shows a surface marked only by striation lines common to pyrite, I assume that the fissuring in the treated sample is caused by the solution acting upon some soluble mineral, probably gold, arranged in plates, occurring in groups, but which, by its color and isomorphism and the extreme tenuity of its lines, is undistinguishable from the mass of pyrite inclosing it."

RESULTS OF EXPERIMENTS WITH POTASSIUM CYANIDE UPON PYRITIC GOLD ORES.

Name of Mine.	Assay Value.		Per Cent Extracted.	
	Gold, Oz. per Ton.	Silver, Oz. per Ton.	Gold.	Silver.
Oregon pyrites	18.825	15.3	28.9	26.7
Murchie pyrites	6.730	24.6	83.4	22.7
Calaveras pyrites	5.925	32.0	94.8	68.6
Shasta pyrites	15.260	11.8	80.5	85.4
Alaska pyrites	2 110	0.5	82.0	84.48
Terror pyrites	0.440	5.7	63.6	6.7
Boulder ore	0.600	trace	79.4	....
Plymouth Consolidated pyrites	6.875	...	87.5	....
Plymouth Consolidated pyrites (roasted)	11.250	....	93.8	....
North Carolina pyritic ore	0.723	....	68.0	....
North Carolina pyritic ore	4.500	....	90.0	....
Zinc blende, concentrates	1.560	....	84.0	....

The experiments on the Oregon pyrites were conducted by Mr. C. W. Merrill, and, as will be seen, were a failure. This ore yielded 90% by chlorination of the roasted ore. A partial analysis of it was as follows:

SiO_2	23.109	Arsenic	6.304
Fe	36.590	Sb	.522
S	33.620	Total	100.125

By amalgamation the ore yielded nothing. After deflagration with bicarbonate of soda and decomposition by acid, the residue under a powerful microscope showed no gold whatever.

Mr. Merrill believes the poor results with this ore to be due to the gold being completely surrounded by the particles of mineral, so that it did not come into contact with the solution. Four solutions of different strengths were tried on another sample of this ore, with the following percentage results:

Strength of Solution.	Gold Extracted.	Silver Extracted.
0.12	9.1	10.5
0.25	17.1	19.4
0.5	13.5	14.2
1.0	10.97	14

This indicates that an increase of strength beyond 0.5% has apparently no beneficial effect.

The pyrites from the Murchic mine are considered the most rebellious of California pyritic ores. When treated by the chlorination process, an attempt to extract a portion of the silver by adding salt on the last hearth of a reverberatory furnace resulted in a large loss of the gold by volatilization. The gold extracted by chlorination was about 85% of that remaining in the roasted ore, while subsequent lixiviation with calcium hyposulphide extracted only 25% of the silver, together with a little more of the gold.

Considering the character of the ore, which contained a considerable percentage of arsenical pyrites, the extraction by cyanide was good. And if this result, notwithstanding the low extraction of silver, could be maintained, this process would be more profitable than the chlorination process formerly used. The cost, unless the pyrites had become oxidized by exposure to moisture and the atmosphere, would be considerably less than that for chlorination.

The experiments on the Calaveras pyrites were made by Mr. C. W. Merrill. The ore was nearly pure silica and pyrite, and by raw amalgamation yielded about four per cent of its contents. After deflagration with bicarbonate of soda and treatment with acid, coarse gold was observed under the microscope. The following results were obtained by use of cyanide solutions of varying strengths:

Strength of Solution.	Gold Extracted.	Silver Extracted.
0.25	51.4	20.2
0.50	65.8	19.1
1.00	87.4	24.8

The table shows that increasing the strength of the solution had marked beneficial results. Mr. Merrill believes that this was due to the accessibility of the gold to the solution. The result, 94.8%, was obtained after two treatments, the first yielding 86.16% of gold and 45.13% of silver.

The Shasta and Alaska pyrites were of the common type and the results were fair. The Boulder ore was arsenical iron pyrites. The cost of treating this ore was stated by the Gold and Silver Extraction Company to be $2.50 a ton, not including crushing.

The Plymouth Consolidated pyrites were concentrates consisting of iron pyrites with a small proportion of galena, and were treated by roasting, in a reverberatory furnace 84 ft. long, and subsequent chlorination. The cost by this process was $9.44 a ton, and the average result from Jan. 15, 1884, to April 15, 1885, was an extraction of 95.23% These concentrates varied in value from $107 to $150 a ton before roasting, and from $146 to $207 a ton after roasting. The treatment of these pyrites raw, thus saving roasting expenses amounting to $5.74 a ton, would hardly be profitable, for between $9 and $12 per ton more than by chlorination would be lost in the tailings, and in all probability the consumption of cyanide would be large owing to the presence of sulphates. No saving would be effected by treating the ores by cyanide after roasting, since chlorination then costs but $3.70 per ton.

The North Carolina pyrites were experimented upon by R. M. Eames & Son. The ore was iron pyrites disseminated through slate-rock. The solution was comparatively strong, two per cent, and the time five days. Another sample of ore was treated which analyzed as follows:

Silica	60.30	Sulphur	9.50
Alumina	9.00	Magnesia	2.00
Iron	12.00	Lead, manganese, and lime	traces.
Copper	6.00		

The results on this ore, which assayed three oz. of gold to the ton, were very poor, the extraction being but five per cent.

The zinc blende concentrates were treated by Mr. C. W. Merrill. An analysis of this ore was as follows:

	Per cent.
Silica	49.31
Sulphide of copper	.18
Pyrite	6.43
Galena	6.39
Blende	37.69
Total	100.00

This ore yielded 33% of its gold by free amalgamation. After deflagration with bicarbonate of soda, leaching with water, and decomposition by acid the residue showed a nugget of free gold.

Mr. Merrill ascribes the poor results on this ore to the great affinity of zinc for cyanogen, which rendered inert the affinity of cyanogen for gold; but the good results obtained from the Black Jack concentrates of the Ravenswood mine, Queensland, which are now treated by chlorination, show that this theory is probably erroneous. The interference of this mineral cannot be considered proved as yet. In all probability it was the presence of iron salts, not showing an acid reaction, which caused the difficulty.

Experiments were made by the State Mining Bureau of California on pyrites typical of those reduced in the chlorination works at Sutter Creek, Cal., and assaying 5.1 oz. gold per ton. The following results, showing the effect of time on the efficiency of cyanide, were obtained with a one per cent solution:

Time in Hours.	Extraction, Per Cent.
2	64.71
3	68.63
4	69.63
6	74.51
8	78.44

These sulphurets in physical condition were as fine as those treated by chlorination.

After grinding the ore through a 100-mesh screen 82.36% of the gold was extracted, and after grinding in an agate mortar and digesting with three different solutions of cyanide the extraction was 90.2%. A second lot of sulphurets ground through a 120-mesh screen yielded 90.6% of their gold after 8 hours' digestion with a 1% solution.

Conclusions and Deductions.—It will be seen that many favorable results have been obtained by the experimental treatment of pyritic ore, but it must be remembered that in these tests with large excesses of chemicals the important factor of cost does not enter. This cost, as will be explained in another place, does not arise from mechanical difficulties, but is, owing to chemical troubles, due almost solely to the decomposition of the solution by salts which are always present in partially decomposed pyritic ore. It may be and probably is quite possible to neutralize these salts by alkalies; but even then the cost will be high, for the excess of chemicals which must be used has a tendency to increase the consumption of cyanide and of zinc in the precipitating bases.

In South Africa no success has been obtained as yet with this class of ore, and it seems more than doubtful if it ever will be. The field in this country is still open, however, to intelligent work in this direction. To effect economical and successful working, the constituents of the ore must be known and their variations in composition discovered in time to modify the treatment so as to secure the best results.

THE PLANT.

It has been stated that the cyanide process is so simple that the plant may consist of old barrels or tanks, placed together in any way, with crushing machinery of any description. The absurdity of such a statement is apparent to the metal-

lurgist, but not always to the miner. The process is not complicated, it is true, but it is far from being simple; and a proper arrangement of the plant not only increases the percentage of extraction and the capacity of a mill, but reduces working expenses. With low-grade ores financial success is often due to the perfect mechanical arrangement of the metallurgical plant.

Before discussing the plant in detail, it will be well to consider the comparative merits of rolls and stamps, and of wet or dry crushing in preparing ore for lixiviation.

THE ADVANTAGES OF DRY CRUSHING BY ROLLS.

Where the ore is to be leached raw, without roasting, rolls possess many advantages over stamps, besides the very decided one of first cost.

First, the uneven product of the stamps and the large percentage of dust and slimes cause the ore to leach slowly. As the number of tanks used for lixiviation depends upon the leaching rate, this increases the number of tanks required, and consequently both the first cost and the operating expenses.*

So much is the leaching of raw ores delayed by fineness that at Silver City, New Mexico, where the tailings from the Bremen mill, ground fine in pan-amalgamation, were leached by the Russell hyposulphite process, the rate of leaching, although aided by the use of pumps to exhaust the air from the bottom of the tank, fell as low as $\frac{1}{16}$ in. per hour. The rate for raw ores crushed through a 20-mesh screen by rolls would be at least 6 in. per hour, and probably more.

Dry crushing by rolls is also preferable for other reasons. If the ore is crushed wet, it must be run into settling tanks, or else directly into the lixiviating tanks. If it is run into settling tanks, extra handling is necessitated; and in either case the ore is deposited in layers according to the size and specific gravities of its constituents. The heavier and more rebellious minerals fall to the bottom, and the lighter particles, settling last, form a coating almost impervious to the solution. It is true that a partial mixture is effected when the ore is shoveled into the tanks; but it is partial only, and the slimes, which do not mix with the other ore, render leaching difficult. This difficulty occurs also in agitation, the method first proposed for treating ores by the cyanide solution. If the ore is agitated with the solution and finally allowed to settle, the supernatant liquid can be recovered

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* Some 92% of the ore crushed dry by stamps through a 30-mesh screen and 88% of that crushed through a 26-mesh screen will pass through a screen of 60 meshes to the inch. The following table gives an idea of the fineness of the product crushed wet through a 20-mesh screen:

Pulp resting on 20-mesh screen	= 0%	Pulp resting on 100-mesh screen	= 7.1%
" " " 30 " "	= 43.0%	" " " 120 " "	= 4.8%
" " " 50 " "	= 29.5%	" " " 150 " "	= 4.2%
" " " 57 " "	= 5.3%	" " " 150 " "	= 7.8%

It will be seen that while 92% of the pulp crushed dry through a 30-mesh screen passes a 60-mesh screen, only 56.7% of pulp crushed wet through a 20-mesh screen passes a 30-mesh screen.

At the Mercur mine, Utah, where the cyanide process is in successful operation, the following results in screening the pulp were obtained by C. W. Merrill:

29%	passed a	4-mesh screen.
60%	"	12 " "
26%	"	30 " "

Of the 26% passing the 30-mesh screen the greater portion was impalpable powder.

When working quartzose ores it has been found that when crushed by rolls through a 16-mesh screen less than 25% passed a 30-mesh screen.

and the metals precipitated; but that remaining in the ore, say 500 lbs. to the ton, containing not only its *pro rata* proportion of the precious metals, but some 5 lbs. of cyanide to the ton of ore, if a 1% solution is used, costing some $2.50, cannot be recovered without greatly diluting the solution, and then but partially. It is for this reason that agitation has been generally abandoned for the process of lixiviation.

The delivery of the ore to the lixiviation tanks is equally simple when either wet crushing or dry crushing is used, but it is more expensive when settling tanks are employed intermediately.

As, however, the direct discharge of the ore to the tanks from the stamps is impracticable, the uneconomical settling tanks must be used. It is to be admitted that the cost of wet crushing by stamps is less than that of dry crushing by the same means, as the capacity wet is nearly double that dry, the same power being employed in each case; but the lesser cost of rolls, both as to purchase and operation, is so much in their favor that, aside from the indisputable fitness of their product for lixiviation, they must be universally adopted. In fact, rolls are equally well adapted for lixiviation and concentration, as in both processes evenness of product is essential to good work.

A plant for the treatment of ores by the cyanide process differs in a few details from that of any other hydro-metallurgical process for unroasted gold or silver ores. It consists, in brief, of driers for the ore, crushing appliances, conveying apparatus, tanks for lixiviating the crushed ore and for the solution, troughs in which the metals are precipitated, conveniences for the precipitation, and the usual minor details necessary to an economical metallurgical plant.

Driers.—The driers commonly used in dry-crushing silver mills are the common unlined rotary iron drier, which has been until within a few years almost universally used, and the Stetefeldt dry kiln, a modification for this purpose of the Hasnclever furnace. The rotary drier has the merit of low first cost, but the Stetefeldt kiln is cheaper to operate. The Stetefeldt kiln also has the additional advantages of occupying less space and having a greater capacity than the rotary drier, which are no slight merits when grading has to be done. Again, the hottest gases in the Stetefeldt kiln are utilized in drying the wettest portion of the ore, while the reverse of this is the case in the rotary drier. The capacity of the rotary drier is, however, more than doubled by the simple device introduced by R. P. Rothwell of dividing the cylinder longitudinally by iron, or in a roasting furnace by tile diaphragms, into three or more compartments, thus dividing the ore and bringing it up into the hot portion of the cylinder and turning it over more often. A cylinder of this kind was first used at Deloro, Ontario, Canada, and one is now in use at the chlorination works, Deadwood, S. D.

Further crushing of the ore broken by the rock-breaker is done in ordinary rolls crushing to about six-millimeter size, as should be used in the coarse crushing of a concentration plant. The product of these rolls should pass through a double trommel, one a screw having six-millimeter meshes, and the other being sufficiently fine—say one millimeter—to permit the ore passing it to be taken directly to the leaching tanks, while the portion remaining behind in the last screen is sent to the rolls or stamps for recrushing. The proportion of the ore which may be passed directly from the roughing-rolls to the leaching tanks

depends upon its friability, and may amount to from 15% to 25% of the whole. That portion of the ore rejected by the six-millimeter screen is returned to the roughing-rolls. As the ore is crushed dry, the rolls and trommels must be housed and provided with suitable dust-chambers. Only a small quantity of dust is made, however, and this may be mixed with the ore from the final crushing, when its effect upon filtration will be slight.

Conveyors.—If this important portion of the plant is properly arranged, the ore need be handled but once after leaving the drier.

Between the rock-breaker and the drier, if rotary driers are used, there is no conveyance except by gravity; but if the shelf dry kiln is adopted, the broken ore must be elevated in cars to the top of the kiln. This may be obviated, if there is sufficient grade, by placing the top of the kiln below the level of the breaker, or preferably by having the crusher at the ore-bins and taking the broken ore in tram-cars to the top of the dry kiln.

The dried ore from the kiln falls into cars which are wheeled to the rolls and discharged into hoppers. Between the rolls and the trommels there are bucket-elevators. The ore passing over the six-millimeter screen falls back through a chute either to the hoppers or to the rolls direct, the first method being preferable, as the feeding and the wear of the rolls are then uniform. In the same way the ore refusing to pass through the one-millimeter screen is conveyed through a chute to the finishing-rolls, while the fine ore passing the screen falls into a trough in which there is a screw-conveyor. The product from the finishing-rolls is elevated to another one-millimeter trommel, from which the coarser portion is returned by a chute to the rolls. The finer portion passing the screen falls into the screw-conveyor mentioned before, which moves it to either side of the mill. The conveyor shaft and box are placed, if possible, between and slightly above the two parallel rows of leaching tanks running transversely across the mill; there is a slide in the bottom of the conveyor-trough which can be opened to allow the ore to fall into a chute which reaches nearly to the bottom of the tank. This chute is made of canvas, and widens gradually toward the bottom. Its outlet is kept open by an iron ring the weight of which holds it in position, which is changed from time to time by the man in charge of the tanks.

As the tank fills, the feeding is directed toward the sides and the ore spread out evenly. The charging of the tanks is almost automatic and requires but little attention. The particulars of this conveyor system will, of course, vary somewhat with the capacity of the plant, but for a plant of say 40 tons daily capacity the plan would be substantially as described.

Leaching Tanks.—The number and size of the leaching tanks depend upon the capacity of the mill and the time required to treat the ore. Generally the tanks should be charged in every shift of either 8 or 12 hours. The capacity of each tank would therefore be either one half or one third the daily capacity of the mill, and the number of tanks either twice or three times the number of days required to fill and leach a tank, with one or two additional, so that at least one tank may always be empty.

The tanks for the cyanide process do not differ materially from those for any other of the lixiviation processes. They are generally constructed of wood, and

are cylindrical in form, although iron tanks and rectangular wooden tanks have also been used in this country.

The objections to the use of iron tanks are that they are fully as expensive as wooden tanks, are difficult to calk if they leak, and are easily corroded by the solution and the moisture. Rectangular wooden tanks are less expensive than cylindrical tanks of the same material, but it is very difficult to keep them from leaking.

The tanks should be constructed of well-seasond lumber, with staves from three inches to four inches thick, having their inner and outer faces cut to correspond to the arc of circle of the tank, and their edges radial to this circle. The staves should be at least one foot longer than the inside depth of the tank, and gained from one inch to an inch and a half into the bottom timbers, with a chime of several inches. The bottom should be of heavier timber than the sides, tongued and grooved, and put together with white lead or litharge and glycerine. Those who have worked in a mill with leaking tanks improperly constructed know how necessary this latter precaution is. The hoops should be made of wrought-iron rods from three quarters of an inch to an inch and a half in diameter, according to the size of the tank, with threaded ends passing through wrought-iron lugs and tightened by hexagonal nuts. The framework upon which the tanks rest should be built of strong timbers, and should be sufficiently high to allow easy access to the bottom of the tanks. When the tanks are of large diameter these hoops are made in sections.

The tanks when finished should be painted with paraffine paint or a mixture of asphaltum and coal-tar. The use of white lead, except in joining the bottom where it is not exposed to the action of the solution, must be avoided.

The filters are usually constructed of wooden slats supporting a burlap filter. Perforated slate slabs have been proposed, and it would seem advantageous to use them or else perforated porcelain tiles, as in the tanks for the filtration of the gold solution from the ore in the modern chlorination process. The tiles do not absorb gold as does the wood. The slats are usually two inches high and one inch wide, and are fastened to the bottom one inch or less apart. This should be done with wooden pins. Grooves three fourths of an inch deep and at least three inches wide are cut in a number of places in the bottom to allow the free passage of the solution along the bottom. Between the ends of the slats and the inside of the tank an annular space about an inch and a half wide is left, which is partly filled by a strip of wood one inch thick bent to the circle of the tank. Over this and the slats the burlap is spread and held by a rope half an inch in diameter, which is driven into the space remaining between the strip of wood and the staves of the tank.

The discharge-pipe is made of heavy six-ply rubber hose, two inches in diameter, inserted into the tank through a three-inch plank fastened by screws to its bottom. The hole for the hose is bored at an angle of 30°, and ends at the center of the tank. The joints are made with white lead, and the hose is fastened to the tank by wooden pins. The hose discharges into an asphalt-coated launder, which leads to the zinc precipitation-boxes or to another tank.

The tailings in a well-constructed mill should be sluiced out of the tanks by water under a slight pressure. This materially reduces the cost of discharging

the tanks. The sluice-gate is from 18 to 20 in. wide and 8 in. high. The door is covered with a strip of blanket or rubber. For large tanks there should be two of these placed opposite each other. The bottom of the gate is flush with the surface of the filter.

The size of the tanks depends upon the capacity of the mill and the rate of leaching. An increase in diameter increases the amount of ore leached per charge, but an increase in depth does not. The weight of a cubic foot of dry crushed ore varies from 75 to 110 lbs., depending upon the mineral constituents and the fineness of the grains. The weight per cubic foot being determined, it is a simple matter to calculate the size of the tanks to be used. It is rarely convenient, except where very large charges are treated, as at the tailings mills in South Africa, to make the net inside depth of the tanks over 60 in. A tank with this depth and a diameter of 20 ft. contains nearly 100 tons of an average ore, and a tank 14 ft. in diameter and of the same depth contains about 50 tons. It is much better, where room is plentiful, to increase the diameter than to increase the depth of the tanks.

The pipes leading to the tanks should be about two inches in diameter, and three in number for each tank—one for the cyanide solution, another for the wash-water, and a third for the caustic-alkali solution, in case it is used. These should be placed at the sides of the tanks just above their edges. The cocks and valves should be of iron, although on the wash-water pipes cocks of any metal may be used.

Solution Tanks.—The tanks for the cyanide solution are constructed substantially the same as the leaching tanks, with the exception of the filter. They are frequently placed below the level of the floor, but this arrangement is undesirable, as repairs cannot be easily made. Their number and capacity depend entirely upon the strength of the solution and the capacity of the mill, and whether the circulation method is used. This method reduces the quantity of solution required, but has its drawbacks, which are explained elsewhere. In general, it may be said that in a mill of 100 tons daily capacity, using an 0.8% solution, and working on ore carrying half an ounce of gold to the ton, requires 100 tons, or about 3000 cu. ft. of solution for actual leaching purposes. In addition to this, however, there should be a surplus of not less than 50%, which would increase the necessary capacity of the storage tanks to 4500 cu. ft.

Dissolving Tank.—A tank constructed in the ordinary manner is needed in dissolving the cyanide. This is used for several reasons; viz., the cyanide is dissolved more readily; there is less extra solution to handle; the operation of bringing the working solution up to its normal strength is more easily effected; and the so-called carbide of iron, which commonly is an impurity of the commercial cyanide, is left in the tank and does not enter the working solution. The strong solution, if impurities are present in large quantities, is siphoned from this tank into the storage tanks, but is ordinarily drawn off through a valve, the inlet of which is covered with iron or steel wire gauze.

A tank is also required, if the ore has an acid reaction, for the caustic-alkali solution. Enough of this solution must be used to saturate the ore, generally from 7 to 10 cu. ft. per ton. The construction of this tank should be similar to that of the other tanks.

Pumps and Pipes.—Several pumps are used to raise the solution from the sumps to the solution and lixiviation tanks, and to provide circulation if this process is used. They may be of ordinary construction, except that no part which comes into contact with the solution should be of brass. The pipes are of iron, and vary from two to three inches in diameter, the largest size being used to convey the water for sluicing.

Zinc Precipitating-boxes.—The zinc precipitating-boxes are usually constructed of wood, but it is well to use a less absorbent material. They are from 14 to 20 ft. long and about 2 ft. deep, and are divided into compartments from 1½ to 2 ft. long. These compartments are each filled with from 30 to 40 lbs. of zinc shavings, which rest on a tray, the bottom of which is an iron-wire sieve. The solution flows alternately upward and downward through these compartments. One compartment at the head is left empty to permit any impurity, such as sand, to settle. At the outlet end a double compartment is left open to catch the gold which may be mechanically carried by the solution. If both a weak solution and a strong solution are used in leaching, a double set of zinc boxes is employed.

Plant for Treating the Precipitate.—The plant for treating the precipitate consists of furnaces over which the precipitate freed from the greater portion of the zinc is dried, and in which it is melted in black-lead crucibles. The ordinary wind bullion-melting furnace answers this purpose, but it should be constructed with dust and fume chambers with alternate up and down takes, in order to collect as much as possible of the zinc oxide which is produced. Otherwise this and the considerable quantity of gold it contains is lost. In many cases, however, the zinc oxide has no commercial value, and is saved for the gold alone. A muffle furnace, in which a partial oxidation of the zinc is effected previous to melting, is also used in some localities. In this country it will be more profitable in most cases to sell the precipitate to smelters than to attempt to refine it.

The Assay Plant.—The assay office has the ordinary crucible and muffle furnaces, or a muffle of sufficient size to hold crucibles. These are for the assays of crude ore, tailings, and bullion. As the process is of a chemical nature, and subject to many puzzling changes in its operation, the assay department should have a competent chemist, and be provided with the apparatus necessary to determine the more common metals and to test the strength of the solution and of the crude cyanide. This apparatus, with the necessary stock of chemicals, is not expensive, and should always be provided. Its use will help the process when successfully working, and, when a failure is being made, will frequently place the metallurgist upon the right track. The assay office is in reality the most important part of a cyanide plant, and its thorough equipment should not be neglected.

THE LIXIVIATION OF THE ORE.

Wash-water.—When the ore reaches to within six inches of the top of the tank, wash-water, if the ore contains soluble salts, is allowed to fill the tank until the ore is slightly covered. Actual practice alone determines how long this water should be allowed to remain in contact with the ore, but in most cases a few hours are sufficient.

Treatment by Caustic Alkali.—If the ore requires subsequent neutralization

by caustic alkalies, the wash-water is run down to the surface of the ore and then the alkaline solution is run on until the tank is filled. This solution is allowed to remain in contact with the ore for some time. Attempts have been made to do away with the use of this caustic solution by mixing lime with the ore; but it is readily seen that, should an excess be added, the consumption of cyanide will be increased, owing to the lime causing double decomposition with the carbonate of potassium always accompanying commercial cyanide of potassium, and forming insoluble carbonate of lime and caustic potash. The caustic potash causes an excessive consumption of zinc in the precipitation-boxes, and in addition very probably reacts on some of the metallic components of the ore, forming compounds which are dissolved by cyanide, and which cause a loss in its solvent action on the precious metals, besides producing a base precipitate if these metals are precipitated by zinc.

The Cyanide Solution.—The weak caustic-alkali solution is allowed to remain in contact with the ore the length of time found necessary, and when drawn down to the surface is followed by a charge of the strong working solution, which replaces the alkali solution. The alkali solution is allowed to run away until it gives a reaction for cyanogen by any of the well-known tests, such as ferrous sulphate. The outlet is then stopped, and the cyanide solution allowed to fill the tank to a point just above the surface of the ore. This solution, like the preceding ones, remains in contact with the ore for at least 12 hours. The strength of the solution varies according to the ore, from one fourth of one per cent (5 pounds of cyanide to the ton of water) to eight tenths of one per cent (16 pounds of cyanide to the ton of water). The presence or absence of base metals determines this point. In general it may be said that an excess of cyanide above the amount which is found to work most advantageously is deleterious, as greater opportunity is given for the decomposition of the solution by the atmosphere and carbonic acid, and for the extraction of base metals. After the necessary time has elapsed, this first solution, which carries the greater portion of the gold extracted, is allowed to flow away to the precipitation-boxes, and is replaced by other solutions. This lixiviation is continued, according to the rebelliousness of the ore, from 12 to 24 hours, these being practically the extremes. To determine whether extraction is still going on, a sieveful of bright zinc shavings is exposed to the action of the solution. If the zinc is discolored after an hour's time by metallic precipitates, leaching must be kept up until there is no such deposition. The rate of leaching depends entirely upon the physical condition of the ore: the finer it is the slower the rate. It varies between one inch per hour with fine material to nine inches per hour with coarse quartzose granules.

The Weak Solution.—The solution after leaving the zinc boxes frequently contains an appreciable percentage of free and active cyanide of potassium. This is utilized by pumping it back onto the ore, after the first one or two charges of strong solution have gone through. The saving effected by this is considerable, as it lessens the amount of strong solution required over the consumption by decomposition.

If the weak solution is used the operation is continued as described, except that this solution after leaving the tanks is diverted to its own separate precipitation-boxes, where the precipitates formed are decidedly poorer.

Agitation of the Ore and Solution.—As this was the original method proposed, although it has been invariably unsuccessful wherever tried, it is still attracting some interest. There are, however, several objections to its use. First, the decomposition of the cyanide, exposed to the action of the atmosphere more than in the lixiviation system, is abnormally high. The tailings assay low, showing a large apparent extraction, but all of the gold cannot be recovered, as it is impossible to free the ore from solution after it is run into the leaching tanks. The power required to stir a large quantity of ore is also considerable, being at least one horse-power per ton. The method has been attempted unsuccessfully with several wet processes, notably the Russell hyposulphite lixiviation process at Bullionville, Nev.

Circulation of the Solution.—This consists in pumping the solution flowing out of the tank back again without precipitating the gold already in solution. This method has been adopted at several South African works, but in absence of any definite data upon the subject the financial success of the method is open to doubt, although, as stated before, it has several favorable features. Similarly, when circulation is used in the Russell hyposulphite process a precipitate is found on top of the ore, which contains considerable gold and is ultimately lost. The pumping heats the solution, causing more rapid decomposition and a greater solvent energy for the base metals.

Lixiviation and precipitation, with or without a return of the solution freed from its contents of precious metals, must be considered the approved method.

Final Wash-water.—When it is found that the solution leaving the tank no longer contains an appreciable amount of gold, the cyanide solution is allowed to rise to the surface of the tank, and wash-water in a sufficient quantity to displace the cyanide solution is added. Seven to nine cubic feet per ton, or from 437.5 to 562.5 lbs., is usually required. This fills the tank to a certain depth, known by experience. The outlet is then opened and the solution allowed to flow to the zinc boxes until the wash-water has sunk to the surface of the ore, after which the water is allowed to run to waste. An appreciable loss of cyanide occurs here, which cannot well be avoided.

Sampling the Tailings and Ore.—Before the tanks are discharged, samples of the tailings are taken for assay. This is usually done with a long-handle, semi-cylindrical probe, which is driven to the bottom of the tank and then lifted out with the tailings adhering. Samples should be taken from different parts of each tank, and those from each tank, with the sample taken after the first wash-water, and before the cyanide solution is run on, must be kept separate for a check on the working of each tank. The original value of the ore is determined from samples taken at the rolls.

It is well to often assay separately samples from the bottoms of the tanks and from the sides, to determine if the extraction has differed locally, for the solution in an improperly charged tank has a tendency to flow down the sides. This is remedied by tamping.

Discharging the Tailings.—In a mill constructed as before described the tailings are sluiced out by water under head, or by the pressure of a fire-pump should a natural head be wanting. The operation is simple and rapid. The sluice-gates are opened and the head of water partially turned on. The sluiceways carrying

the tailings must be large enough and have a sufficient fall to allow the stream to run rapidly away to the dump. If the tanks are discharged by hand the cost is much greater, being from 10 to 15c. per ton, while it is less than 1c. per ton when water under a head is abundant.

Precipitation of the Gold.—Since the cyanide process has been used on a large scale, a number of precipitants have been tried; but with the possible exception of the Malloy process, which will be spoken of later, the only one which has proved successful is metallic zinc in the form of shavings. Zinc dust precipitates the gold, but it is impermeable to the solution. Sheet zinc offers too small a surface to the solution, and the same objection is open to granulated zinc. Sheet zinc forming the poles of a galvanic battery has been tried, it is said, successfully on an experimental scale.

This is undoubtedly the weakest point of the cyanide process, and it is to be hoped that some means other than the present will be devised by which the bullion may be recovered in a purer state and the solution be less affected.

The zinc shavings are prepared by turning in an ordinary lathe, a cylindrical block being made of a number of disks of sheet zinc placed on a spindle. The expense is considerable, two men being employed on this work constantly in works of large capacity. Nor can the prepared shavings be shipped, as not only would they be extremely bulky, but the bright surface would become oxidized, diminishing their efficiency for precipitation. These shavings are placed in the compartments of the precipitation-boxes already described. Those in the first few compartments are more vigorously attacked than elsewhere, as the greater portion of the gold is precipitated here. These compartments are, therefore, replenished from time to time with fresh shavings from the last compartment where those directly from the lathe are placed.

The gold is precipitated as a blackish or, under certain conditions, as a whitish powder. To remove the gold precipitate, which is generally done every two weeks, the iron screen upon which the shavings rest is first lifted from the lugs on which it rests. The finely divided gold in the boxes is then allowed to settle for an hour or so, after which the supernatant liquor is siphoned off, without disturbing the precipitate. The boxes are then cleaned out and the slimes and water allowed to drain through a fine screen, and the gold and the fine zinc which remain in the screen are rubbed through it by means of a stick with a piece of rubber fastened to its end. The remaining portion, consisting almost entirely of unconsumed zinc, is placed in the first zinc boxes on top of a fresh lot of zinc shavings.

The matter which has passed the screen, consisting of metallic gold and silver, metallic zinc, lead and tin derived from the zinc, some sand and organic matter, and a small amount of copper, is allowed to settle in the tank, under the screen. It is then ready for drying and treatment for the production of bullion. It seems probable that much trouble could be avoided in the drying and melting and in the treatment of the precipitate by acid, if used, by employing a filter press such as Johnson's, which is used in the pressing of sulphides from the hyposulphite process. This press is simple and easily managed. The precipitate could be drawn by a vacuum from the tank into which the slimes are screened, and forced by steam-pressure into the press and there subjected to a

pressure which, although they would still contain a considerable quantity of water, would leave them in a more convenient form for subsequent treatment. They would then have to be dried and melted. After drying, however, they would be in a good condition for treatment by any of the proposed acid processes.

Treatment of the Auriferous Precipitate.—The slimes are transferred to enameled iron pans and dried over a fire. This is a tedious operation, requiring considerable time and care. When dried, the usual course is to transfer the precipitate mixed with sand, borax, and bicarbonate of soda to a graphite crucible, where it is melted little by little, more being added as the precipitate melts. When the pot is full it contains at the Robinson Works, where a No. 6 crucible is used, from 100 to 150 oz. of bullion. As large quantities of zinc oxide are given off in the melting, and carry off a considerable amount of gold, the furnace should be provided with suitable dust and fume collecting chambers.

Various schemes have been devised to perfect this portion of the process. One method consists in roasting the slimes in a muffle furnace and volatilizing a portion of the zinc as an oxide. These furnaces may be constructed like the Belgian zinc distillation furnaces, the retorts being made of fire-clay, and a condenser and a sheet-iron drum being placed at the mouth to save the zinc oxide and the gold, which is volatilized. The bullion produced after following this process would be of considerably higher grade than that produced without a previous roasting, and is much less bulky. The bullion now made is of a whitish color and varies from 650 to 800 fine.

Sulphuric and hydrochloric acids have been tried for dissolving the zinc after the soluble cyanide salts had been leached out, but the difficulty of freeing the slimes from the soluble cyanides and afterward from the zinc sulphate by filtration prohibits their use. An acid sodium sulphate may be used for dissolving the zinc, the reaction in this case being:

$$2NaHSO_4 + Zn = ZnNa_2 2SO_4 + H_2,$$

leaving the gold, silver, and a portion of the other metals behind.

THE CHEMISTRY OF THE PROCESS.*

Solution of the Gold.—The solubility of gold in a solution of cyanide of potassium has long been known, as is shown in another section. Elssner claimed (*J. Pr. Chem.*, xviii.) that the presence of oxygen is necessary for the reaction after the formula:

$$2Au + 4KCy + O + H_2O = 2KAuCy_2 + 2KHO.$$

That is, a double cyanide of gold and potassium is formed. This was proved by the formation, upon evaporating the solution, of octahedral crystals answering to the formula. To my mind, however, the necessity of oxygen has not been proved, and I consider that the following reactions are more correct:

$$Au + 2KCy + H_2O = KAuCy_2 + KHO + H.$$

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* In this section I must express my indebtedness to Messrs. Butters and Clennell for matter derived from their excellent and thorough papers in the *Engineering and Mining Journal* of Oct. 22 and 29, 1892.

It certainly seems more logical that there should be a simple interchange between the gold and the potassium, forming metallic potassium, which decomposes in the nascent state the water of the solution, than that there should be another element necessary to the reaction. The theory of the second reaction is upheld by experiments made by myself, which showed that strongly concentrated solutions of potassium cyanide have less solvent energy upon metallic silver than the weaker ones. This I supposed (for I did not make any attempt to prove the reaction) was due to the polarizing action of the hydrogen. In this case minute bubbles covering the cement silver could readily be seen. Which of the two is the actual reaction plays but little part in the working of the process, however. There will be few complaints of an insufficiency of oxygen, as, according to the reaction, but 15.96 parts of oxygen by weight are required to dissolve 396.6 parts of gold. The probabilities are, however, if oxygen is required at all, that it must be present in larger quantities, as no hydro-metallurgical process works in practice in exact accordance with the simple chemical formula. If the cyanide process in particular did so, only 130.04 parts of cyanide of potassium would be lost in dissolving 196.8 parts of gold, or, more correctly, 2 parts of cyanide to 3 parts of gold; but in reality the quantity consumed amounts, on the freest ore, to 3 lbs. to the ounce of gold recovered, or 43.7 parts of cyanide to one of gold. On more refractory ores containing soluble base metals, and particularly acid salts, the consumption is greatly in excess of this.

Solubility of Other Metals and Minerals.—According to Gmelin, zinc, iron, nickel, and copper are dissolved by potassium cyanide, with evolution of hydrogen; cadmium and silver in the presence of oxygen; and tin, mercury, and platinum not at all. Sulphide of silver is dissolved by strong solutions and a sufficient quantity of weak solution. Silver arsenate (Ag_3AsO_4) and silver antimonate (A_9Sb_3O) are readily dissolved by potassium cyanide, as are many of the argentiferous arsenical and antimonial minerals found in nature. Chloride of silver dissolves readily, forming chloride of the alkali and a double cyanide of silver and potassium. While metallic silver when sufficiently fine dissolves readily in the solution, that found native in ores is not attacked unless existing in thin laminæ. The oxides and sulphides of copper are attacked by the solution and dissolved, as is metallic copper. It is claimed that the presence of copper sulphide in a silver or gold ore prevents the precious metals from going into solution. Although experiments have shown that little or no silver or gold is dissolved in certain ores containing sulphide of copper, this question is by no means settled, as artificially prepared sulphide of silver is dissolved in actual contact with the copper compounds. Metallic iron is attacked, but very slowly. Ferric hydrate is not attacked by the solution, but ferrous hydrate formed in the neutralization of the iron salts by alkali is attacked by cyanide, according to the reaction:

$$Fe2HO + 6KCy = K_4FeCy_6 + KOH.$$

Thus ferrocyanide of potassium and caustic potash are formed.

Treatment of Pyritic Ore Previous to Lixiviation with Cyanide.—Pyritous ore if but slightly exposed to atmospheric action always contains free sulphuric acid and soluble salts of iron. To prevent reactions on the solution it is necessary to leach these ores with water previous to lixiviation with cyanide of potas-

sium and before washing with an alkali. If the alkali solution was added directly to the ore, the consumption of alkali would be extremely large and the amount of solution necessary, if lime was used, would prove inconvenient to handle.

The alkali solution, assuming that caustic soda is used, reacts on basic iron salts, insoluble in water, according to the following reactions:

$$Fe_2O_3,SO_3 + 2NaHO + H_2O = Fe_2(HO)_6 + Na_2SO_4$$

and

$$Fe_2O_3,2SO_3 + 4NaHO + H_2O = Fe_2(HO)_6 + 2Na_2SO_4.$$

Thus ferric hydrate and sodium sulphate (or calcium sulphate, if lime is used) are formed. Sodium sulphate is soluble and passes off with the wash-water, but calcium sulphate remains. The hydrate of the sesquioxide of iron is insoluble in water and to all appearances is unattacked by the cyanide solution; but, as has been mentioned before, the hydrate of the protoxide is dissolved with formation of ferrocyanide of potassium. Mr. C. W. Merrill precipitated ferrous hydrate by caustic potash from a cyanide solution. The solution contained but a small percentage of free cyanide, however, as it had already acted on ore and zinc in the precipitation of the dissolved gold, and it is unlikely that this reaction, regenerating the cyanide of potassium, which had been rendered inert by the solution of the iron, would occur in a comparatively strong solution.

Direct Treatment of Pyritic Ores by Cyanide of Potassium.—As has been explained, the direct treatment of these ores is inadvisable and extremely expensive. Pyrite (FeS_2) is decomposed by the oxygen of the air and moisture into soluble ferrous sulphate and free monohydrated sulphuric acid, according to the reaction:

$$FeS_2 + H_2O + 7O = FeSO_4 + H_2SO_4.$$

The ferrous sulphate is decomposed by the action of the air to insoluble basic sulphates. In addition normal ferric sulphate (Fe_23SO_4) is produced, which gradually loses acid and becomes a soluble basic sulphate, $Fe_2O_32SO_3$. There are many basic salts of somewhat complex and doubtful composition formed likewise. Thus in an oxidized ore which has contained pyrite are found sulphuric acid, ferrous sulphate, basic ferrous sulphates, ferric sulphate, and basic ferric sulphates, all of which react upon potassium cyanide. Sulphuric acid reacts upon potassium cyanide with evolution of hydrocyanic acid according to the reaction :

$$2KCy + H_2SO_4 = K_2SO_4 + 2HCy.$$

Ferrous sulphate reacts upon cyanide with the formation of ferrous cyanide, a yellowish-red flocculent precipitate:

$$FeSO_4 + 2KCy = FeCy_2 + K_2SO_4.$$

This ferrous cyanide is attacked by the excess of cyanide in the solution, and ferrocyanide of potassium is formed according to the reaction:

$$FeCy_24KCy = K_4FeCy_6.$$

That is to say, one molecule of ferrous sulphate decomposes or renders inert six molecules of cyanide of potassium. Other things being equal, if 1%, or 20 lbs., of ferrous cyanide existed in the ore, some 51 lbs. of cyanide would be rendered inert for the solution of gold, and in fact would be lost. This at the average price of chemically pure cyanide would cost over $30 per ton.

The ferrocyanide of potassium formed according to the last reaction is re-acted upon if sufficient acid be present by an additional quantity of ferrous sulphate with production of prussian blue according to the reaction:

$$3KFeCy_6 + 6FeSO_4 + 3O = Fe_2O_3 + 6K_2SO_4 + Fe_7Cy_{18}.$$

This production of prussian blue gives a blue color to the surface of the tailings, or to the solution, and indicates at once that the washing and neutralizing operations have not been carried on properly and that a great loss of cyanide is taking place.

Ferric salts, when present unmixed with ferrous salts, decompose the cyanide solution with formation of hydrocyanic acid and precipitation of ferric hydrate, according to the reactions:

$$Fe_2(SO_4)_3 + 4KCy = Fe_2Cy_6 + 3K_2SO_4.$$

With further decomposition:

$$Fe_2Cy_6 + 6H_2O = Fe_2(OH)_6 + 6HCy.$$

This means that, other things being equal, one molecule of ferric sulphate decomposes six molecules of cyanide. If 1%, or 20 lbs., of ferric sulphate existed in the ore, very nearly the same weight of cyanide, costing $12, would be destroyed.

If a mixture of ferric and ferrous sulphate, as is probable, exists in partially oxidized ores, it causes the production, when ferrous sulphate is in excess, of ferrous ferrocyanide, according to the reaction,

$$12KCy + 3FeSO_4 + 4Fe_2(SO_4)_3 = Fe_3(FeCy_6)_2 + 6K_2SO_4;$$

when ferric sulphate is in excess, the production of ferric ferricyanide (prussian blue), according to the reaction,

$$18KCy + 3FeSO_4 + 2Fe_2(SO_4)_3 = Fe_4(FeCy_6)_3 + 9K_2SO_4.$$

These reactions show clearly that washing by water and neutralization by a caustic alkali must be employed to arrive at satisfactory and economical results. It is more than probable that many of the failures already recorded are due to the lack of these precautions. In addition to these reactions there are many with unknown compounds, the composition of which cannot be expressed, even where the greatest precautions are used and the operations supervised with the greatest ability and knowledge.

Precipitation of the Gold.—Zinc precipitates the dissolved gold, as the cyanide has more affinity for it than for the gold.

The theoretical reaction is

$$2KAuCy_2 + Zn = 2Au + K_2ZnCy;$$

but much more zinc goes into solution than this reaction calls for. The consumption in South Africa, as a matter of fact, is one pound of zinc to one ounce of gold, instead of one pound of zinc to six pounds of gold, as called for by the reaction. This excessive consumption of zinc must be ascribed to other action than the mere replacement of zinc for gold in the double cyanide of gold and potassium.

There is comparatively little exact knowledge of the reactions taking place in the zinc precipitation-boxes. One fact is known positively, and that is, that hydrogen is evolved. This does not occur, however, when zinc alone is exposed to a cyanide solution, but after gold is deposited on the zinc, or when zinc is placed in contact with iron. In other words, a galvanic couple is formed, the water is decomposed, and hydrate of zinc is formed, which is attacked by the cyanide forming a double cyanide of zinc and caustic potash. The probable reactions may be expressed as follows:

$$Zn + 2H_2O = 2H + Zn2(HO).$$
$$Zn2(HO) + 4KCy = ZnK_2Cy_4 + 2KHO.$$

This production of caustic alkali explains the increased alkalinity of the solution after passing the zinc precipitation-boxes. It may be considered advantageous to a certain extent, however, as carbonic acid, which decomposes the solution, is absorbed by the caustic potash, with formation of a carbonate of the alkalies. Ammonia is formed also, as is indicated by the strong odor of that gas about the boxes.

The precipitate contains, besides the precious metals, many of the base metals, which may be dissolved by the solution. The principal of these are copper, arsenic, and antimony, and, in the condition in which it is refined, large quantities of zinc and the impurities of the zinc. An incomplete analysis of the precipitate formed at the Mercur Works, Fairfield, Utah, is here given:

Zinc	39.1	Sulphur	2.6
Calcium carbonate	36.7	Iron	2.4
Gold	4.4	Undetermined residue	6.0
Cyanogen	3.5		

The gangue of the ore here treated is a silicious limestone, and the line in the precipitate can thus be accounted for, but in what manner it has become reunited with carbonic acid is a mystery.

It would seem improbable that calcium cyanide, formed in the first place by the reaction of cyanide on the calcite, was decomposed by the hydrate of zinc, formed in precipitation, with formation of caustic lime, which in turn was changed to carbonate by atmospheric action, for the consumption of cyanide would in this case be much higher than it is in reality (1.27 lbs. per ton); yet this sequence of reactions, however improbable, is the only way in which we can account for it, unless we consider the carbonate of lime to be dissolved by the alkaline solution without decomposition. In this case it might be reprecipitated by several of the reactions which occur in the zinc boxes.

According to information which I have received, there are no less than three works where the zinc has failed to precipitate the gold, and that metal, although leached from the ore, is not to be found in the solution. Careful and intelligent work will probably show where it is.

The Malloy Precipitation Process.—This process, which is said to be in successful operation in South Africa, and which certainly seems to have many favorable features, depends upon the use of sodium amalgam. The sodium in the amalgam, when in contact with a solution of gold cyanide, is replaced by gold, and itself enters the solution as sodium cyanide, which is nowise less efficacious in extracting gold than potassium cyanide. Moreover, by its use many of the reactions causing decomposition are avoided, and a purer precipitate is formed. There is also no accumulation of formidable quantities of zinc in the solution.

The sodium amalgam is formed electrolytically from carbonate of soda, and the process of manufacture is simultaneous with the precipitation. The operations are conducted as follows :

The solution passes through a trough containing mercury, in which there is a cylindrical vessel filled with carbonate of soda. The edges of this vessel are held below the surface of the mercury, so that its contents do not come in contact with the solution. The lead anode of a battery dips into the solution of carbonate of soda, the mercury itself forming the cathode. Metallic sodium is formed, which immediately amalgamates with the mercury in the bath, and the resultant sodium amalgam reacts upon the gold cyanide with production of gold amalgam and sodium cyanide according to the reaction:

$$Hg_nNa + KAuCy_2 = Hg_nAu + KCy + NaCy.$$

The advantages of this precipitation process, if it is proved successful, are numerous, but the patent right is in litigation. The late E. N. Riotte made attempts to precipitate gold from cyanide solution by sodium amalgam, but his results were poor, it is said. Analogous difficulties were met with in the early days of the Russell lixiviation process, but after much hard work these were traced to their sources—for there were several—and the remedies found. The cyanide process is essentially a chemical one, and its reaction must be carefully watched.

Decomposition of the Cyanide.—Several of the causes for the at times excessive decomposition of cyanide of potassium have been pointed out in preceding sections, but there are other causes. In the first place, the compound of cyanogen and potassium is extremely unstable. Not only is it decomposed by mineral acids and acid salts, but by the action at ordinary temperatures of atmospheric carbonic acid, according to the reaction:

$$2KCy + CO_2 + H_2O = K_2CO_3 + 2HCy.$$

Hydrocyanic acid is given off, a portion of which remains in solution and is available for the extraction of gold, but the greater part is dissipated into the air.

The cyanide is easily oxidized to cyanate:

$$KCN + O = KCNO.$$

This cyanate is further oxidized to carbonate according to the reaction:

$$2KCNO + 3O = K_2CO_3 + CO_2 + N_2.$$

The nitrogen given off may cause a still further decomposition, for when a current of nitrogen is passed through a cold dilute solution of cyanide of potassium, hydrocyanic acid is evolved without the nitrogen entering into the reaction. This action, when the presence of a chemical causes a reaction between other chemicals in aqueous solutions without entering into the reaction itself, is called hydrolysis, and further reaction must be attributed to this property of caustic alkalies, which are and must be always present in a working solution of potassium cyanide. When a solution of potassium cyanide is treated with boiling alkali solution the following reaction occurs with formation of ammonium formate:

$$HCN + 2H_2O = HCO_2(H_4N).$$

Although this reaction does not occur, since boiling alkalies are not used, analogous ones undoubtedly do, as the following reaction shows:

$$HCu + 2H_2O = H_3N + KHCO_2.$$

That is, ammonium and potassium formate are formed.

Returning to the case of the precipitation of lime, as at the Mercur mill, the following reaction may possibly explain the formation of calcium carbonate, if we presuppose that the lime is in the solution as cyanide of calcium:

$$Ca2(CN) + 3H_2O + 2H = CaCO_3 + 2H_3N + CO_2 + H_2O.$$

Hydrogen is always evolved when the gold is precipitated, and without it the foregoing reaction could not be completed. This reaction accounts, moreover, for the formation of ammonia at the zinc boxes. The carbonic acid evolved attacks the cyanide as mentioned before, thus causing still greater decomposition of the solvent.

It will be seen, therefore, that the decomposition of the cyanide solution and loss of the solvent energy of the solution for gold may be divided under the following heads:

1. Actual decomposition of the solution:
   a. By acids and acid salts present in the ore.
   b. By atmospheric carbonic acid.
   c. By oxidation.
   d. By reaction owing to hydrolysis.
2. The solution of other metals than gold which are not precipitated:
   a. By metals or their compounds present in the ore, as oxides or carbonates of lead, which are first attacked by the caustic alkali. By oxides or carbonates of the alkali. By certain compounds of iron insoluble in water.
   b. By the replacement of gold in solution by zinc in precipitation.
   c. By dissolving zinc hydrate, formed by electrolysis in the precipitation.

It will thus be seen that these losses under incompetent management may be frequent, and in many cases may cause unprofitable results.

Operations in the Laboratory.—One of the tests to be made most frequently is the determination of the cyanide present in the solution—not only the total quantity of cyanogen present, but that available for the extraction of gold and silver. For the determination of the total cyanogen present there are several methods. The one frequently used is to add a standard solution of silver nitrate until a coloration, owing to the precipitation of insoluble silver cyanide, appears. As this method is not accurate, however, with solutions containing zinc and other metals, it will not be discussed. An easier and more accurate method is by titration with a standard solution of iodine in potassium iodide until a blue coloration is apparent, a starch solution having been added to the cyanide solution. The reaction is as follows:

$$KCy + I_2 = KI + ICy.$$

The solution may be checked on chemically pure cyanide, or, better yet, on sodium hyposulphite, and the cubic centimeters equivalent to one per cent of potassium cyanide calculated.

For testing the percentage of available cyanide, the method devised by Mr. Bettels of the Robinson Gold Mining Company's works in South Africa, and described by Messrs. Butters and Clennell, is undoubtedly the best yet introduced: "Two perfectly clean flasks of equal size are taken. To each of these is added a considerable bulk, say 50 cc. of the solution to be tested and 50 cc. of water. The liquid in both flasks will probably appear slightly turbid, but the degree of turbidity will be the same in each. Standard silver-nitrate solution is run into one flask until the slightest possible increase in turbidity is observed on comparison with the liquid in the other flask. This point is taken as indicating the conversion of the whole of the *free* cyanide of potassium into the soluble silver salt, and, therefore, as determining the amount of available cyanide present."

If the percentage of zinc in the solution is required, the solution is evaporated to degrees and the residue treated by any of the well-known methods of analysis for zinc. If the amount of gold is required, the residue is scorified and the lead button cupelled.

A test as to the acidity of the ore should be made so as to calculate the amount of neutralizing alkali required. For this a quantity of the washed ore may be stirred in a solution of carbonate of soda of known strength. The solution is then filtered, the pulp thoroughly washed, and the solution treated with a standard solution of sulphuric acid until carbonic acid gas is no longer given off. The difference between the percentage of carbonate of soda originally in the solution and that remaining is the quantity on which the ore has reacted. The percentage of caustic soda, or caustic lime, may be calculated from this. The result is sufficiently accurate as a guide for practical work. The precipitate is not homogeneous, and cannot be sampled accurately, so the assayer is rarely called upon to determine the gold or silver present if it is treated at the mine. Should it be shipped, however, it will be necessary to determine the value. In this case the greatest care must be taken in sampling the sieved and dried precipitate.

Ten grams of the final sample being weighed out, they are digested in nitric acid in a beaker. Sodium chloride is then added to precipitate the silver, and the

residue washed upon a filter. After it is washed, the filter-paper and its contents, being incinerated with care in a porcelain crucible, is placed in a scorifier with, say, 30 grams of granulated lead, spread out with a hollow place at the center. The ashes and metals are then covered with 20 grams of lead, a few grams of borax are sprinkled over the top, and the whole scorified. When the "eye" is about the size of a half-dime the scorifier is removed from the muffle and the contents poured into a clean iron mold. The lead button, after the usual precautions have been taken, is cupelled. Of course this assay is made in duplicate or triplicate, and the average taken, unless there is a marked variance between them. The bullion samples, if bullion is made, should be taken by dips from the molten mass when cleaned of slag. These are granulated in *hot* water, as cold water makes irregular spatters of it, instead of those of more or less even size. These are secured, and the usual quantity weighed out for assay. In cupellation the zinc forms a gray slag, and undoubtedly there is a considerable loss of gold by volatilization with the zinc oxide. However, checks of the approximate composition of the alloy can be assayed and the loss determined.

In assaying ore or tailings it is convenient to use a large quantity of ore, preferably 30 grams (in lieu of the usual assay ton), for in the former case one milligram of cupelled gold is equal, close enough for all practical purposes, to $20 per ton, and all decimal parts on the beam of balance are therefore read at once in dollars. A No. 10 French crucible is large enough for this purpose.

IRON AND STEEL.

By William B. Phillips, Ph.D.

(Unless expressly stated to the contrary, the ton used is of 2240 lbs.)

Iron ore was first mined in the United States in the early part of 1608, for in April of that year about 35 tons were exported from Jamestown, and yielded 17 tons of metal when smelted in England. But it was not until the early part of the present century that the industry assumed even the most moderate proportions, as the output of ore in 1810 could not have exceeded 100,000 tons. The statistics of iron-ore production prior to 1850 are not available, but it is unlikely that in any previous year it amounted to more than 1,600,000 tons, as the maximum yearly output of pig-iron was 800,000 tons.

The following table gives the production and value of iron ore by States in the census years from 1850 to 1890:

IRON ORE IN THE UNITED STATES.

PRODUCTION AND VALUE BY STATES, 7TH TO 11TH CENSUS, 1850 TO 1890.

Tons of 2240 lbs.

	1850.		1860.		1870.		1880.		1890.	
	Production.	Value.	Production.	Value.	Production.	Value.	Production.	Value.	Production.	Value.
		$		$		$		$		$
Alabama	1,838	6,770	3,720	19,765	11,350	30,175	171,139	201,865	1,570,319	1,511,611
Conn., Me. & Mass.	66,266	489,905	69,550	448,845	78,925	528,750	92,549	382,927	88,251	265,901
Delaware and Md.	99,866	560,725	79,200	528,750	138,067	758,510	127,101	428,244	29,380	68,240
Georgia and N. C.	6,089	28,630	2,700	8,600	5,546	23,686	84,583	148,907	258,961	334,025
Kentucky	72,010	262,152	98,750	517,628	126,562	670,278	57,865	165,905	77,487	135,559
Michigan	2,700	14,000	114,410	686,460	859,507	4,297,535	1,948,334	6,034,648	5,856,169	15,800,521
Missouri	37,000	97,367	35,000	181,750	126,212	586,293	344,818	1,674,875	265,718	561,041
New Jersey	51,266	332,707	107,972	665,285	362,636	2,103,288	745,000	2,910,442	415,510	1,341,523
New York	46,385	321,027	151,378	1,018,772	446,945	2,609,794	1,126,900	3,654,872	1,247,537	3,100,216
Ohio	140,610	630,037	288,977	1,291,778	558,664	3,763,282	488,750	1,269,530	254,294	532,725
Pennsylvania	877,283	3,732,427	1,351,000	7,014,037	2,337,286	13,277,525	1,951,495	5,517,079	1,560,234	3,063,534
Tennessee	88,810	254,900	56,969	203,764	64,988	178,655	93,272	147,181	473,294	619,476
Texas	....	....	3,250	13,420	2,500	12,000	3,214	8,100	13,000	19,750
Va. and W. Va.	67,319	158,307	28,109	132,894	84,108	315,108	217,444	530,943	511,255	935,290
Wisconsin	3,000	8,250	5,500	21,150	49,106	257,491	37,000	73,000	837,399	1,840,908
Total	1,560,442	6,897,204	2,396,485	12,732,898	5,250,402	29,412,370	7,489,464	23,148,518	13,458,808	30,130,320
Additions	18,876	84,475	5,000	24,950	52,550	431,050	8,045	8,437	1,060,049	3,234,638
Grand total	1,579,318	6,981,679	2,401,485	12,757,848	5,302,952	29,843,420	7,497,509	23,156,955	14,518,857	33,364,958

Additions.—To census year 1850: Illinois, 5500 tons, value $15,500; Indiana, 5200 tons, value $24,400; New Hampshire, 500 tons, value $4900; Vermont, 7676 tons, value $40,175.

To 1860: Illinois, 4000 tons, value $20,000; Indiana, 1000 tons, value $4950.

To 1870: Indiana, 51,150 tons, value $426,050; Mississippi, 800 tons, value $3000; South Carolina, 600 tons, value $2000.

To 1880: Indiana (irregular), 513 tons, value $1018; Oregon, 6972 tons, value $4169; Vermont, 560 tons, value $2750.

To 1890: Colorado, 109,136 tons, value $487,433; Idaho and Montana, 24,072 tons, value $158,974; Minnesota, 864,508 tons, value $2,478,041; New Mexico and Utah, 36,050 tons, value $70,956; Oregon and Washington, 26,283 tons, value $39,234.

IRON ORE IN THE UNITED STATES.

EMPLOYEES AND WAGES—1 TON=2240 LBS. 11TH CENSUS, 1890.

	Employees above Ground.															
	Foremen.				Mechanics.				Laborers.				Boys under 16 yrs.			
	No.	Days worked.	Wages. Per day.	Wages. Total.	No.	Days worked.	Wages. Per dav.	Wages. Total.	No.	Days worked.	Wages. Per day.	Wages. Total.	No.	Days worked.	Wages. Per day.	Wages. Total.
			$	$			$	$			$	$			$	$
Alabama.	54	259	2.36	33,006	79	241	1.94	36,736	1,533	227	1.20	417,589	96	236	0.53	12,008
Colorado.	14	177	4.88	12,092	26	219	3.86	21,979	101	186	2.99	56,170	2	74	2.00	296
Conn. Me & Mass	8	313	2.44	6,109	26	308	1.65	13,213	149	277	1.36	56,131	..	...	...	......
Del. &Md.	10	224	1.52	3,404	.....	...	....	....	208	200	1.00	41,600	14	225	0.57	1,796
Ga.&N.C.	41	214	1.93	16,934	24	214	1.49	7,653	573	208	1.03	122,760	37	219	0.57	4,619
Id. & Mon	5	253	3.15	3,985	1	150	3.00	450	64	171	3.03	33,160	..	...	...	......
Ky........	5	212	1.25	1,325	5	275	1.50	2,063	340	180	1.03	63,036	25	212	0.75	3,975
Michigan	147	289	2.98	126,599	948	285	2.00	540,360	2,904	255	1.60	1,184,832	82	283	0.83	19,261
Minn.....	21	276	3.27	18,952	93	276	2.26	58,010	611	233	1.90	270,490	17	219	0.86	3,202
Missouri..	11	297	2.10	6,861	41	289	1.80	21,328	310	254	1.20	94,488	11	253	0.48	1,364
N. J......	24	308	2.61	19,293	152	280	1.48	62,989	289	272	1.21	95,116	27	274	0.62	4,587
N. Mex. & U. T.	2	306	3.75	2,295	.....	...	...	....	10	286	3.50	10,010	..	...	...	......
N. Y	50	296	2.44	36,112	257	293	1.66	125,000	1,020	268	1.20	328,032	21	264	0.64	3,548
Ohio.	36	264	1.93	18,342	42	223	1.44	13,487	755	186	1.03	144,643	9	154	0.59	818
Oregon & Wash.	1	273	4 50	1,229	4	273	3.50	3,822	7	252	2.44	4,304	..	...	....	......
Penn.....	110	241	1.69	44,802	159	240	1.70	64,872	2,599	214	1.10	611,804	170	245	0.58	24,157
Tenn	32	259	2.15	17,819	31	257	1.93	15,376	1,162	217	1.05	264,762	88	245	0.58	12,505
Texas....	2	170	2.29	779	2	224	0.50	224	82	253	0.53	10,995	1	44	0.50	22
Va. & W. Va.	86	210	1.98	35,959	74	183	1.65	22,588	1,402	201	1.02	287,438	104	146	0.52	7,806
Wis......	21	262	2.77	15,241	115	292	2.04	70,182	412	257	1.68	177,885	5	265	1.20	1,590
Totals....	680	258	2.40	421,056	2,079	274	1.90	1,082,327	14,531	228	1.29	4,273,858	709	221	0.62	97,147

IMPORTS OF IRON ORE INTO THE UNITED

The figures prior to 1879 are not obtainable, but in no previous year did the imports

Customs Districts	1880.		1881.		1882.		1883.		1884.		1885.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value
		$		$		$		$		$		$
Baltimore	170,308	506,560	375,798	1,005,496	243,182	654,629	236,998	612,626	184,521	357,136	75,887	155,803
Boston	2,155	13,359	716	2,867	1,664	3,322	2,470	5,277	2,865	7,765	212	838
Buffalo Creek....	13,554	36,426	2,492	7,320	273	755	.....	....	.....	......	10	40
Cuyahoga	13,858	48,463	10,500	37,675	9,420	33,181	6,525	17,810	30,964	121,154	10,630	37,001
Detroit	456	1,169	617	1,646	48	98	......	....	10	27	100	300
Genesee	5,390	16,274	8,716	25,961	6,851	21,651	784	1,740	758	1,897	.. ...	......
New York.........	148,987	432,678	196,419	641,344	145,909	421,776	36,800	94,236	29,401	82,995	18,853	44,071
Oswegatchie......	7,553	21,052	3,418	10,650	905	2,783	942	2,866	......	....	3,172	9,470
Oswego	4,185	7,860	13,612	44,026	37,635	120,008	17,862	40,744	11,179	27,856	......	......
Perth Amboy	5,444	15,968	13,671	48,323	31,558	101,859	10,082	29,189	50,836	124,257	21,271	32,090
Philadelphia......	120,619	335,119	155,564	394,952	111,944	279,818	170,420	386,386	169,507	388,900	259,990	512,780
Puget Sound	400	412	1,100	1,622	......	....	3,521	7,084	2,012	4,024	180	3[illegible]0
Vermont..........	.....	....	......	....	......	....	2,979	5,758	1,831	7,125	360	1,443
All other..........	499	1,469	264	770	266	684	1,402	4,275	3,936	10,542	121	7,097
Total..........	493,408	1,436,809	782,887	2,222,652	589,655	1,640,564	490,875	1,207,991	487,820	1,133,678	390,786	801,293

The following tables show the position of five of the principal States in the order of production of the several kinds of ore, according to the census of 1880 and 1890:

1880.

Brown Hematite.	Red Hematite.	Magnetite.	Carbonate.
Pennsylvania	Michigan	New York	Ohio
Michigan	Missouri	New Jersey	Pennsylvania
New York	Pennsylvania	Pennsylvania	Delaware and Maryland
Virginia and West Virginia	New York	Michigan	Virginia and West Virginia
Alabama	Tennessee	Virginia and West Virginia	Kentucky

1890.

Brown Hematite.	Red Hematite.	Magnetite.	Carbonate.
Pennsylvania	Michigan	New York	Ohio
Virginia and West Virginia	Alabama	Pennsylvania	New York
Alabama	Minnesota	New Jersey	Kentucky
Michigan	Wisconsin	Michigan	Pennsylvania
Georgia and North Carolina	Tennessee	Georgia and N. Carolina	Delaware and Maryland

IRON ORE IN THE UNITED STATES.

EMPLOYEES AND WAGES—1 TON=2240 LBS. 11TH CENSUS, 1890.

Office force.		Employees below Ground.															
		Foremen				Miners				Laborers				Boys under 16 yrs.			
				Wages.				Wages.				Wages.				Wages.	
No.	Total Wages.	No.	Days worked.	Per day.	Total.	No.	Days worked.	Per day.	Total.	No.	Days worked.	Per day.	Total.	No.	Days worked.	Per day.	Total.
	$			$	$			$	$			$	$			$	$
41	37,170	8	274	2.95	6,466	598	245	1.92	281,299	706	256	1.47	265,682	7	161	0.67	755
23	26,425	11	233	3.99	10,226	205	248	3.00	152,520	29	208	2.68	16,166	3	129	1.69	654
2	1,200	8	256	2.13	4,362	193	257	1.40	69,441	40	264	1.33	14,045	...	...	....	......
1	1,200	...	...	....	....	......	...	....	....	.....	...	....	....	...	...	....	.....
16	14,725	3	308	2.12	1,959	10	202	1.20	2,424	91	297	0.68	18,579	1	244	0.40	98
...	.....	2	180	3.69	1,328	11	162	3.14	5,595	...	...	....	....	...	...	....	......
8	7,500	...	...	....	....	......	...	....	....	.....	...	....	....	...	...	....	......
173	217,283	304	291	2.69	237,968	5,341	274	2.23	3,263,458	3,199	272	1.73	1,505,321	22	277	1.17	7,130
15	25,299	37	296	3.00	32,856	498	259	2.55	328,904	478	255	1.96	238,904	...		....	......
23	29,874	17	284	2.16	10,428	238	265	1.58	99,651	73	236	1.36	23,430	5	276	0.45	621
21	14,440	68	295	1.90	38,114	944	268	1.39	351,659	353	280	1.24	122,562	15	288	0.68	2,938
1	1,000	...	...	....	....	35	259	3.50	31,728	.....	...	...	....	...	...	..	.....
46	43,050	71	280	2.15	42,742	1,085	278	1.47	443,395	623	261	1.37	222,766	5	106	0.79	419
34	17,560	9	222	1.95	3,896	674	192	1.25	161,760	60	161	1.25	12,075	25	100	0.51	1,275
...	....	...	...	....	....	35	235	2.56	21,056	.....	...	....	....	...	...	.	.....
40	26,814	41	224	1.67	15,337	1,065	230	1.39	340,480	216	227	1.12	54,916	10	300	0.90	2,700
19	12,460	5	214	3.04	3,253	176	204	1.20	43,085	20	288	1.00	5,760	1	200	1.00	200
2	365	...	...	....	....	.....	..	...	....	.....	..	....	....	...	...	....	......
32	23,257	43	252	1.74	18,855	514	252	1.13	146,367	201	176	1.00	35,376	12	262	0.50	1,572
23	29,421	59	304	2.69	48,248	810	273	2.00	442,260	390	251	1.81	177,181	5	219	1.14	1,248
520	529,043	686	282	2.46	475,892	12,432	261	1.91	6,197,476	6,479	261	1.60	2,705,630	111	216	0.82	19,610

STATES, 1880 TO 1892, CALENDAR YEARS.

amount to 100,000 tons. In that year they were 284,141 tons, valued at $681,467.

1886.		1887.		1888.		1889.		1890.		1891.		1892.	
Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value	Tons.	Value
	$		$		$		$		$		$		$
358,364	630,072	401,035	686,891	119,570	251,110	273,050	519,736	481,250	1,015,093	453,373	1,219,015	328,326	758,033
....	......	412	1,356	.....	....	50	283	....	....	......	......	.....	......
781	2,358	....	....	.....	....	78	198	82	185	114	342	1	3
14,351	42,576	6,893	21,262	13,122	39,066	1,224	3,403	4,675	15,460	.....	......	.....	......
......	....	......	....	......	....	18	36	....	....	44	75	.....	......
....	....	....	....	......	....	.....	....	....	....	......	......	.....	......
59,992	140,105	53,520	95,465	23,615	47,792	25,824	72,297	38,717	101,908	25,817	89,975	23,533	61,260
18	60	84	600	.....	....	2,309	6,353	12,617	23,446	1,958	3,591	8,605	17,196
....	....	....	......	......	....	.....	....	....	......	.....	......	.....	......
23,903	65,282	45,289	118,214	56,393	128,383	11,558	26,075	25,524	50,984	14,089	42,087	4,428	8,153
576,077	1,011,202	675,680	1,250,672	367,439	823,841	525,124	1,192,141	683,665	1,641,654	416,846	1,098,992	438,920	940,783
3,872	7,744	1,229	2,458	6,901	13,816	13,670	27,860	....	....	588	2,189	2,568	9,598
......	....	....	....	83	455	462	707	239	258	.....	......	.....	......
2,075	13,038	10,159	30,040	347	6,126	206	3,303	61	5,130	35	280	204	621
1,039,433	1,912,437	1,194,301	2,206,958	587,470	1,313,589	853,573	1,852,392	1,246,830	2,854,118	912,864	2,456,546	806,585	1,795,647

Nearly all of the imported ore comes from Spain, Algeria, and Cuba. It is for the most part Bessemer ore, and the amount of pig-iron made from it has not at any time reached 10% of our total production.

If the cost of a ton of ore be referred to the amount required for producing a ton of pig iron,—certainly the most equitable means of comparison,—Oregon had an advantage in 1880 of 15c. per ton over any other State, with a cost of 94c., Wisconsin being next with $1.09, and Alabama third with $1.74.

But in 1890 Alabama mined the cheapest ore by 12c., with $1.91 per ton, Pennsylvania coming next with $2.03, and Oregon and Washington third with $2.12.

Of the total amount of ore raised in the United States in 1880, viz., 7,120,361 tons, brown hematite comprised 1,918,622 tons, or 27%; red hematite, 2,243,992 tons, or 31.54%; magnetite, 2,134,276 tons, or 30.03%; and carbonate, 823,471 tons, or 11.43%.

IRON ORE IN THE UNITED STATES.

EMPLOYEES, WAGES AND COSTS—1 TON=2,240 LBS. 10TH CENSUS, 1880.

	Employees.							Cost per ton of Ore and of Ore for 1 ton of Iron.			
	Above Ground.		Administration	Below Ground.		Total.	Total Wages.	Wages.	Supplies.	Total Cost.	
	Men.	Boys.		Men.	Boys.		$	$	$	Per ton Ore. $	Ore in 1 ton Iron. $
Alabama	571	33	19	109	6	738	123,342	0.750	0.107	0.857	1.74
Conn. Me. & Mass.	313	25	20	244	...	602	187,325	2.024	0.725	2.749	5.11
Del. & Md.	311	33	20	12	...	376	63,003	1.163	0.455	1.618	3.69
Ga. & N. C.	290	5	25	69	...	389	112,855	1.663	0.137	1.800	3.62
Kentucky	242	25	13	45	...	325	69,319	2.316	0.271	2.587	6.50
Michigan	2,019	196	210	3,120	17	5,562	2,573,857	1.569	0.572	2.141	3.60
Missouri	1,358	90	77	358	10	1,893	417,371	1.210	0.304	1.514	2.54
New Jersey	1,259	93	126	3,264	69	4,811	1,606,257	2.236	0.866	3.102	6.43
New York	1,893	140	190	2,417	35	4,675	1,507,395	1.367	0.482	1.849	3.62
Ohio	989	43	44	602	38	1,716	329,723	1.857	0.134	1.991	4.04
Oregon	2	.....	1	11	...	14	2,210	0.355	0.098	0.453	0 94
Pennsylvania	4,810	583	386	2,892	62	8,733	2,192,107	1.349	0.323	1.672	3.60
Tennessee	419	32	24	77	...	552	83,529	1.040	0.108	1.148	2.25
Va. & W. Va.	669	38	10	488	...	1,205	250,264	1.213	0.208	1.421	3.57
Vermont	8	.....	.....	7	...	15	1,500	3.000	1.072	4.072	9.34
Wisconsin	36	3	1	20	2	62	17,000	0.459	0.060	0.519	1.09
Totals and averages	13,179	1,359	1,166	13,735	239	31,668	9,537,057	1.512	0 458	1.970	3.85

IRON ORE IN THE UNITED STATES.

EMPLOYEES, WAGES AND COSTS—1 TON=2,240 LBS. 11TH CENSUS, 1890.

	TOTAL.		Costs per ton of Ore and of Ore for 1 ton Iron.								
			WAGES.				Contract Work.	Supplies and Materials.	Other Expenses.	Total Cost.	
	Employees.	Wages.	Above ground.	Below ground.	Office.	Total.				Per ton of Ore.	Ore in 1 ton Iron.
		$	$	$	$	$	$	$	$	$	$
Alabama	3,122	1,032,392	0.311	0.353	0.023	0.687	0.055	0.082	0.025	0.849	1.91
Colorado	414	297,297	0.829	1.646	0.242	2.717	.....	0.536	0.032	3.485	6.35
Conn. Me. & Mass.	426	161,894	0.856	0.996	0.0'4	1.866	.....	0.690	0.205	2.761	6 27
Del. & Md.	233	49,416	1.593	.....	0.045	1.638	0.014	0.177	0.150	1.979	4.15
Ga. & N. C.	796	144,921	0.588	0.089	0.057	0.734	0.209	0.179	0.194	1.316	3 23
Id. & Mon.	83	53,112	1.560	0.288	.....	1.848	....	0.650	0.136	2.631	....
Kentucky.	383	72,456	0.908	.	0.097	1.005	0.028	0.053	0.285	1.370	2 96
Michigan	13,120	6,353,741	0.319	0.856	0.037	1.212	0.142	0.412	0.480	2.197	3.79
Minnesota	1,770	978,483	0.405	0.695	0.029	1.129	.....	0.485	0.183	1.797	2.99
Missouri	729	283,847	0.467	0.504	0.112	1.083	0.011	0.171	0.239	1.504	2.66
New Jersey	1,893	568,591	0.438	1.243	0.034	1.713	0.379	0.760	0.232	3.085	6.05
N. Mex. & U. T.	48	45,052	0.341	0.880	0.027	1.248	.....	0.217	0.095	1.560	....
New York	3,178	1,087,252	0.395	0.568	0.034	0.997	0.164	0.459	0.149	1.769	3.38
Ohio	1,644	367,855	0.697	0.739	0.069	1.405	0.018	0.094	0.111	1.610	2.88
Ore. & Wash.	47	31,542	0.3 5	0.801	.	1.156	.....	0.161	0.039	1.356	2.12
Pennsylvania	4,410	1,141,239	0.478	0 265	0.017	0.760	0.035	0.192	0.138	1.125	2.03
Tennessee	1,534	355,332	0.656	0.115	0.026	0.797	0.037	0.182	0.104	1.120	2.69
Texas	89	12,188	0.923	.....	0.028	0.951	.....	0.076	0.034	1.061	2.31
Va. & W. Va.	2,468	575,061	0.691	0.395	0.045	1.131	0.015	0.250	0.251	1.647	3.18
Wisconsin	1,840	797,480	0.316	0.799	0.035	1.150	0.177	0.445	0.208	1.980	3 46
Total and average	38,227	14,409.151	0.405	0.647	0.036	1 088	0.108	0.341	0.261	1.772	3.45

In 1890, out of 14,518,041 tons, the amounts were: Brown hematite, 2,523,087 tons, or 17.4%; red hematite, 9,056,288 tons, or 62.5%; magnetite, 2,506,415 tons, or 17.4%; and carbonate, 432,251 tons, or 2.7%.*

Michigan, of all the States, has shown the greatest increase, her production having risen from 2700 tons in 1850 to 5,856,169 tons in 1890. Pennsylvania was first until 1890, when her output of 1,560,234 tons placed her below Michigan and Alabama. The four States of Michigan, Alabama, Pennsylvania, and New York produced in 1890 more than 70% of the iron ore raised. In 1850 Pennsylvania alone produced 55.5% of the total output, and in 1860 56.5%; but her production declined in 1870 to 44%, in 1880 to 26%, and in 1890 to 10.7% of the total output.

* See table of production of different kinds of ore at close of article.

Of the different varieties, Pennsylvania leads in brown hematite, Michigan in red hematite, New York in magnetite, and Ohio in carbonate, mining no other kind. The most famous iron-ore mine in the country is that at Cornwall, Lebanon County, Pa., which has been in operation since 1740, and has yielded more than 10,000,000 tons of magnetite.

The production of brown hematite is more widely extended than that of any other variety of iron ore, as it is raised in 24 States, red hematite in 17, magnetite in 13, and carbonate in 8.

The drift of iron-ore production away from its old centers is very clearly shown by the tables. Within the last 20 years the development of the Lake Superior mines has caused the transference of the greater part of the tonnage from the East to the Northwest. In 1870, out of a total production for the country of 5,302,952 tons, the Lake region produced 908,613 tons—about 17%; in 1880, 26.5%; and in 1890, 52%.

The greatest development has been in the Lake region, in Michigan, Wisconsin, and Minnesota. The following table gives the output of this region for the last 10 years:*

PRODUCTION OF LAKE SUPERIOR IRON ORE MINES FOR THE LAST TEN YEARS.

Range.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Total.
Gogebic......	....	1,022	119,860	747,589	1,303,267	1,424,699	2,016,391	2,847,786	1,825,599	2,973,993	13,260,206
Marquette...	1,305,425	1,548,034	1,480,422	1,627,380	1,851,414	1,918,750	2,634,816	2,993,664	2,512,242	2,666,856	20,540,003
Menominee..	1,047,415	895,634	690,435	880,006	1,193,343	1,191,101	1,796,755	2,282,237	1,824,619	2,261,499	14,263,044
Mesaba.	....	....	....	....	....	....	....	....	....	4,245	4,245
Vermilion....	....	62,124	225,484	304,396	394,252	511,953	844,682	880,014	894,618	1,167,650	5,285,173
Total ...	2,352,840	2.506.814	2,516.201	3.559,371	4,472,276	5,046,503	7,292,644	9.003,701	7,057,078	9,074,243	53,151,671

The largest individual output at the present time is that of the Norrie mine, Gogebic Range, Michigan, which is producing about 1,000,000 tons per annum.

One of the most important improvements of recent years in the treatment of iron ores is the magnetic concentration of lean ores, a system which has found its greatest development in the Champlain district of New York, but which has also been tried with success at the Cranberry mines in North Carolina. The betterment of brown ores by washing and jigging is also being extended with most gratifying results. The average content of metallic iron in the ores of the United States was 51.07% by the census of 1880, and 51.27% by the census of 1890. The richest ores, 60%, are mined in Minnesota, and the poorest, 40.7%, in Georgia and North Carolina. With the exception of the Cranberry mines in North Carolina, which in 1892 produced 18,433 tons, no Bessemer ore of any moment is mined in the Southern States.

PIG-IRON.

The manufacture of pig-iron in the United States seems to have begun about the year 1620, at Falling Creek, 76 miles from Jamestown, Va. No authentic account of the enterprise is now available, but it is certain that it did not reach any considerable development. There is no doubt that the first blast-furnace erected in America was in Virginia, but the first one whose operation was continuous and to which the historian may refer by documentary evidence, was in Massachusetts, near the present city of Lynn. It was built in 1643–44, and went into blast the next year, using the neighboring bog ore. The Lynn furnace

* For tables containing information respecting the ore vessels on the Great Lakes, and the location and dimensions of shipping docks, see close of article.

seems to have cost about £1500, equivalent to about $6000, and to have produced some 8 tons of pig-iron per week, from which was made "bar iron as good as Spanish," and costing £20 per ton. It is interesting to note that one of the first castings made, a pot holding about a quart, is now preserved in Lynn as the forerunner of the greatest iron industry now in existence. The furnace was in blast three or four years, under the direction of Joseph Jenks, the progenitor of the iron-masters of America, the manufacturer of the first dies (for the "pine-tree" shillings) and of the first fire-engine, and the holder of the first patent granted on this side the ocean, in 1646, for an improved saw-mill. The writer trusts he may be pardoned the harmless egotism of saying that his own sons are lineal descendants of this same Joseph Jenks.

The industry thus planted in New England 247 years ago has grown to be the largest source, next to agriculture, of our national prosperity. The little dribble of iron, amounting at most to 8 tons per week, has swelled to 225,000 tons per week, and the tiny charcoal stack has multiplied itself to 700 furnaces, many of which make more iron in a day than the Lynn furnace made in a year.

The first half of the present century was essentially a charcoal-iron epoch; not because more of this kind was made annually than is now the case,—for the reverse is true, as in 1882 and 1890,—but because it comprised by far the greater proportion of the total production. If we take the high-water mark of yearly production of all kinds of iron prior to 1854 as 800,000 tons, an amount which was reached in 1847 and in 1848, it is likely that the production of charcoal iron was about 600,000 tons, or 75% of the total production. In 1854, out of a total of 657,337 tons, the make of charcoal iron was 305,623 tons, or 46.5%. In 1892 the proportion was 5.83%.

Prior to 1838 practically all the iron made in the country was of this variety, and for nearly 50 years, from 1799 to 1844, charcoal iron ruled the market and was the standard of price. During this entire period the fluctuations in value were as marked as they have been since in the anthracite and coke periods, taking 16 years, from 1799 to 1815, to rise from $36.25 to $53.75, and but 5 years, from 1815 to 1820, to sink again to $35.

If the period between 1799 to 1849 be divided into 10 groups of 5 years to the group, it will be seen that in 7 of these the price fell, the average depression being $4.50, while in 3 the price rose, the average advance being $6.77.

The tendency from 1819 to 1849 was steadily downward, viz., from $36.50 to $24.50. The highest price during the 50 years was $53.75, in 1815, and the lowest $24.50, in 1849. The Philadelphia price is quoted.

The oldest furnace in the United States, now standing entire, is the Cornwall Charcoal Furnace, Lebanon County, Pa. It was built in 1742, and was in blast as late as 1882. It is still in good condition.

The first authentic account of the use of bituminous coal in the blast-furnace was given by Col. James Byrd in 1732, and related to the Spotswood Furnace at Massaponax, below Fredericksburg, Va. But it was not until 1819 that the first run of coke iron was made, at Bear Furnace, Armstrong County, Pa., 86 years after the application of this fuel by Abraham Darby in England. The use of coke, however, extended very slowly, for in 1849 there was no coke furnace in blast, and in 1856 in the entire State of Pennsylvania there were only 21 such furnaces.

Raw bituminous coal was first successfully used by Himrod & Vincent, at Clay Furnace, Mercer County, Pa., in 1845. Its greatest consumption has been in Ohio.

Nine years before this, in 1836, anthracite coal was first used in the blast-furnace. The honor of its introduction unquestionably belongs to the Rev. Dr. Frederick W. Geissenhainer, a Lutheran clergyman. He was using anthracite coal at the Valley Furnace, on Silver Creek, Schuylkill County, Pa., when George Crane, of Yniscedwin, South Wales, applied for and obtained the first English patent covering the use of this fuel in the blast-furnace. Its use spread in this country very slowly, for out of 804 furnaces, the total number in 1840, only 6 were making anthracite iron.

During the decade ending with 1854, however, the manufacture of anthracite pig-iron made wonderful progress, for in this year it amounted to 303,067 tons out of a total of 657,337 tons, or 46.09%. It reached its maximum of percentage production in 1863, when out of a total production of 846,070 tons there were 515,748 tons, or 61% of the total production. In 1890, the year of its maximum tonnage output, it amounted to 2,186,411 tons out of 9,202,702 tons, which was but 23.31% of the total production. The proportion in 1892 was 18.97%.

The manufacture of anthracite pig-iron, unlike that of charcoal, has been restricted, from its very beginning, to a few States. It has not flourished outside of Pennsylvania, New York, and New Jersey, although since 1872 Maryland has been credited with 23,434 tons. Massachusetts and Virginia have also made some anthracite iron; but in the former State the maximum yearly output was 9946 tons, reached in 1875, and the industry has been extinct since 1881, and in Virginia since 1876, the maximum output of 6312 tons having been reached in the previous year. We have reliable statistics of the production of all kinds of pig-iron, by States, from 1872 to 1891, the returns for 1892 not yet being at hand. From the table it appears that during this time there have been produced 28,769,241 tons of anthracite iron, of which Pennsylvania has produced 22,117,773 tons, or 77% of the total; New York, 4,610,998 tons, or 16.13%; and New Jersey, 2,017,701 tons, or 7.04%.

Since 1844 the price of anthracite iron has been the standard. It opened in that year at $25.75, fell to $20.88 in 1850, reached its maximum, $59.25, in 1864, and is now selling at the lowest price it has ever touched, $15.50. It is interesting to observe that the highest price came in a year when the production was within two per cent of the highest percentage output. In 1865, when the price had fallen to $46.12, the production of anthracite pig had fallen to 51.54%. In 1855 the production of anthracite iron first exceeded that of charcoal, itself giving place to coke iron in 1875.

The manufacture of coke pig-iron extended very slowly, the output in 1869 being but 29.41% of the total. In 1877, however, it had risen to 45.87%, and in 1892 to 75.20%. This year has also witnessed the largest tonnage output, 6,864,881 tons; and as the use of coke is being rapidly extended, it is likely that within the next 10 years the proportion will reach 85% of the total output of pig-iron. Many new coking coals are being developed, and the quality of the coke made is steadily improving, with better systems of mining and the introduction of coal washers and crushers. Seventeen States are now engaged in its production, as against 3 for anthracite and 17 for charcoal iron.

Taking the total amount of all kinds of pig-iron produced in the United States since 1854 as 114,804,192 tons, the production of anthracite iron has been 40,159,-123 tons, or 35.09%; of coke iron, 60,006,380 tons, or 52.19%; and of charcoal iron, 14,638,689 tons, or 12.72%.

Statistics of the production of pig-iron in this country prior to 1810 are not available, nor are they to be had, year by year, until 1854. Such returns as are to hand covering the period 1810–52 are given in the following table:

UNITED STATES PRODUCTION AND EXPORTS OF PIG-IRON FOR CERTAIN YEARS, 1810–52.

Year.	Production	Exports.	Year.	Production	Exports.	Year.	Production	Exports.	Year	Production	Exports.	Year	Production	Exports.
1810..	54,000	92	1829..	142,000	45	1832..	200,000	46	1846.	765,000	177	1849.	650,000	74
1820..	20,000	....	1830 .	165,000	46	1840..	315,000	24	1847.	800,000	73	1850.	564,755	22
1828..	130,000	10	1831..	191,000	2	1842..	215,000	26	1848.	800,000	14	1852.	500,000	105

The following tables give the total pig-iron production, imports, exports, stocks, and total and per-capita consumption in the United States since 1854; the production of all kinds of iron, by States, from 1872; and of spiegel and ferro-manganese from 1875.

TOTAL PIG-IRON PRODUCTION IN THE UNITED STATES: IMPORTS, EXPORTS, STOCKS, AND TOTAL AND PER-CAPITA CONSUMPTION, 1854 TO 1892.

Year.	Production.						Stocks.					Consumption.		Estimated Population
	Anthracite	Coke & Bituminous.	Charcoal.	Total.	Imports.	Exports	Anthracite.	Coke & Bituminous	Charcoal.	Total	Supply.	Total.	Per Capita in Lbs.	
1854	303,067	48,647	305,623	657,337	....	2,239	......	......	......	......	655,098	Up to 1873 the total consumption is taken as equal to the total supply, no statistics of stocks being available.	55.57	26.4
1855	340,952	55,705	305,501	700,158	98,925	675	......	......	......	......	798,408		65.74	27.2
1856	395,636	62,102	330,776	788,514	59,012	787	......	......	......	......	846,739		67.49	28.1
1857	348,557	69,152	294,929	712,638	51,794	2,782	.....	......	......	......	761,650		59.06	29.0
1858	322,705	52,099	254,743	629,547	41,986	546	... ..	......	......	......	670,987		49.61	29.8
1859	421,201	75,750	253,608	750,559	72,517	1,108	......	......	......	......	821,968		60.07	30.7
1860	463,581	109,132	248,509	821,222	71,498	355	......	.....	......	... ..	892,365		63.57	31.4
1861	365,383	113,423	174,355	673,061	74,026	703	......	......	......	......	746,384		51.99	32.2
1862	419,924	116,685	166,660	703,269	22,247	1,393	......	......	......	......	724,123		49.37	32.9
1863	515,748	141,036	189,286	846,070	31,007	993	.....	......	......	......	876,084		62.88	33.6
1864	610,730	187,611	215,940	1,014,281	102,223	1,462	......	......	......	......	1,115,042		72.91	34.3
1865	428,177	169,359	234,234	831,77[illegible]	50,652	600	......	......	......	......	881,822		56.51	35.0
1866	669,078	239,639	296,946	1,205,663	102,392	1,112	......	......	.. ..	......	1,306,943		82.05	35.7
1867	713,069	284,506	307,447	1,305,122	112,042	625	......	......	......	......	1,416,539		87.40	36.3
1868	797,300	303,600	330,000	1,430,900	112,133	281	......	......	......	......	1,542,752		93.40	37.0
1869	867,098	494,054	350,134	1,711,286	136,975	61	......	......	......	......	1,848,200		109.67	37.8
1870	830,357	508,928	325,893	1,665,178	153,283	1,390	.....	......	......	......	1,817,071		105.57	38.6
1871	854,114	508,928	343,750	1,706,892	216,070	2.080	......	......	......	......	1,920,882		109.[illegible]	39.5
1872	1,223,046	878,730	446,953	2,548,729	264,256	1,318	......	......	......	......	2,811,667		155.70	[illegible]0.5
1873	1,172,101	873,127	515,731	2,560.959	138,132	9,020	81,557	105,370	88,461	275,388	2,965,327		160.04	41.[illegible]
1874	1,073,343	813,137	514,783	2,401,263	54,611	14,320	222,221	193,284	294,919	710,424	2,716,942	2,006,518	105.25	42.7
1875	810,752	846.028	366.955	2,023,735	59,336	7,802	245,306	147,751	286,324	679,381	2,785,693	2,106,312	107.36	43.9
1876	709,443	883 937	275,579	1,868,959	74,171	3,397	239,393	155,625	218,191	613,209	2,619,114	2,005,905	99.50	45.2
1877	834.640	948,165	283,788	2,066,593	59,706	6,859	213,833	140,016	219,678	573,527	2,739,508	2,165,981	104.56	46.4
1878	975,776	1,063,475	261,963	2,301,214	66,504	2,934	202,338	129,315	181,201	512,854	2,938,311	2,425,457	114.01	47.6
1879	1,136,628	1,284,801	320,422	2.741,851	304,171	1,144	299,169	35.067	61,507	395,743	3,557,732	3,161,989	144.81	48.9
1880	1,613,974	1,741,254	479,962	3,835,190	700,864	1.871	157,019	164 845	85,866	426,573	4,929,926	4,503,353	201.10	50.2
1881	1,548,627	2,025,236	570,389	4,144,252	465,031	6,158	80,670	32,585	75,045	188,300	5,029,698	4.841,398	210.96	51.4
1882	1,823,337	2,176,765	623,130	4.623,232	540,159	5,576	95,767	140,353	147,535	383,655	5,346,115	4,952,460	210.69	52.6
1883	1,683,568	2,401,473	510,469	4,595,510	322,648	3.768	150,017	153,395	164,266	467.678	5,298,045	4,830,367	200.74	53.9
1884	1,416,476	2,272,091	409,302	4,097,869	184,268	3,840	159,815	171,290	198,359	529,464	4,745,975	4,216,511	171.27	55.1
1885	1,298,562	2,388,959	357,003	4,044,524	146,740	6,227	60,873	103,555	207,457	371,885	4,714,501	4,342,616	172.50	56.4
1886	1,874,640	3,398,369	410,317	5,683,326	361,768	8.849	45,092	63,066	117,470	225,628	6,408,130	6,182,502	240.35	57.6
1887	2,087,846	3,813,076	516,234	6,417,156	467.522	6.796	101,881	105,337	85,765	292,983	7,103,510	7,810,527	297.12	58.9
1888	1,719,401	4,235,704	534,633	6,489,738	197,236	14,374	95,106	105,590	99,438	300,134	6,965,583	6,665,449	248.19	60.1
1889	1,714,600	5,313,772	575,268	7,603,640	148,759	13,573	69,198	77,475	101,706	248,379	8,038,960	7,790,581	273.25	61.4
1890	2,186,411	6,388,146	628,145	9,202,702	134,955	16,341	146,697	304,734	157,489	608,920	9,569,695	8,960,775	320.49	62.6
1891	1,866,108	5,836,798	576,964	8,279,870	67,179	14,945	124,369	258,678	213,374	596,421	8,941,024	8,344,603	292.76	63.9
1892	1,797,113	6,822,266	537,621	9,157,000	70,125	15,427	119,015	213,615	173,486	506,116	9,823,458	9,301,915	320.06	65.1

N.B.—Up to and including 1870 imports and exports are in fiscal years; since 1870 in calendar years. In column of estimated population 1 = 1,000,000.

PRODUCTION OF SPIEGELEISEN AND FERRO-MANGANESE IN THE UNITED STATES FROM 1875 TO 1892.

Years.	Tons.	Years.	Tons.	Years.	Tons.	Years.	Tons.
1875	7,000	1880	17,502	1885	30,956	1890	133,180
1876	5,907	1881	18,827	1886	42,841	1891	127,766
1877	7.900	1882	19,610	1887	42,480	1892	179,131
1878	9,530	1883	21,941	1888	48,901		
1879	12,438	1884	30,261	1889	76,627		

CONDITION OF BLAST-FURNACES IN THE UNITED STATES FROM 1874 TO 1892.

Year Ending Dec. 31.	Anthracite.			Bituminous and Coke.			Charcoal.			Total.		Grand Total.	Average Output per Furnace. Tons of 2240 Lbs.			
													By Fuel.			By No. in Blast.
	In Blast.	Out of Blast.	Total.	In Blast.	Out of Blast.	Total.	In Blast.	Out of Blast.	Total.	In Blast.	Out of Blast.		Anthracite.	Bit. and Coke.	Charcoal.	
1874	131	90	221	81	96	177	153	150	303	365	336	701	8,193	10,039	3,365	6,579
1875	100	125	225	98	109	207	95	186	281	293	420	713	8,107	8,633	3,862	6,907
1876	85	143	228	78	128	206	73	207	280	236	478	714	8,346	11,332	3,775	7,919
1877	86	137	223	74	133	207	93	183	276	270	446	716	9,705	12,813	3,051	7,735
1878	87	137	224	76	133	209	84	186	270	265	427	692	11,216	14,000	3,119	8.684
1879	162	63	225	123	88	211	103	164	267	388	309	697	7,016	10,445	3,111	7,066
1880	155	71	226	140	73	213	151	111	262	446	255	701	10 413	12,437	3,178	8,600
1881	160	63	223	144	75	219	151	123	274	455	261	716	9,680	14,064	3,777	9,108
1882	161	64	225	127	83	210	129	123	252	417	270	687	11,325	17,140	4,830	11,087
1883	118	104	222	105	116	221	84	156	240	207	376	683	14,267	22,871	6,077	14,969
1884	84	135	219	86	134	220	66	164	230	236	433	669	16,863	26,420	6,201	17,364
1885	105	103	208	111	91	202	60	121	181	276	315	591	12,367	21,522	5,950	14,654
1886	125	76	201	143	58	201	63	112	175	331	246	577	15,000	23,765	6,513	17,170
1887	118	82	200	147	61	208	74	101	175	339	244	583	17,694	25,939	6.962	18.930
1888	105	84	189	156	82	238	71	91	162	332	257	589	16,375	27,152	7,530	19,547
1889	104	71	175	169	56	225	59	77	136	333	203	536	16,486	31,442	9,750	22,833
1890	101	72	173	143	100	243	59	76	135	303	248	551	21,647	44,672	10,646	30,372
1891	94	66	160	164	88	252	48	73	121	306	227	533	20,000	35,590	12,020	27,058
1892	69	90	159	128	128	256	39	79	118	236	297	533	25,000	53,632	13,650	38,646

MONTHLY PIG-IRON PRODUCTION IN THE UNITED STATES, 1891 AND 1892.

	Anthracite.		Coke.		Charcoal.		Total.	
	1891.	1892.	1891.	1892.	1891.	1892.	1891.	1892.
January	169,924	170,069	437,966	623,430	53,014	49,526	660,904	843,025
February	143,345	158,202	330,497	602,939	41,876	45,788	515,718	806,929
March	153,025	163,753	314,445	643.510	42,010	48,942	509.480	856,205
April	144,933	151,284	284,693	585,338	37,803	43,807	467,429	780,429
May	150,295	150,168	369,492	579,478	41,410	46,589	561,197	776,235
June	145,532	138,223	464,951	552,747	42,896	45,263	653,379	736,233
Total first half-year	907,054	931,699	2,202,044	3,587,442	259,009	279,915	3,368,107	4,799,056
July	166,201	135,200	567,110	544,378	48,228	42,159	781,539	721,737
August	155,156	126,359	581,981	521,182	51,742	41,276	788,879	688,817
September	149.102	123,418	581,762	508,136	57,130	41,157	787,994	672,711
October	160,728	134,911	632,793	557,378	56,189	42.588	849,710	734.877
November	159,530	133,564	630.513	563,786	52,174	41,936	842,217	739,286
December	168,337	138,016	640,595	582,579	52,492	43,334	861,424	763,929
Total second half-year	959,054	791,468	3,634,754	3,277,439	317,955	252,450	4,911,763	4,321,357
Total for year	1,866,108	1,723.167	5,836.798	6,864,881	576,964	532,365	8,279,870	9,120,413

NOTE.—These figures are prepared from monthly estimates of production. The figures for 1891 and the first half of 1892 are corrected to coincide with those given by the Iron and Steel Association. Those for the second half of 1892 are estimated. By previous experience I can say that they are within two per cent of the exact figures.

The per-capita consumption of pig-iron in Great Britain was 381.02 lbs. in 1872; it fell to 311.58 lbs. in 1879, rose to 440.16 lbs. in 1883, and is now about 346 lbs. The smallest per-capita consumption in Great Britain since 1872 is but a few pounds less than our greatest, while the greatest is 120 lbs. more than our greatest consumption.

PRODUCTION OF ALL KINDS OF PIG IRON, 1872-1892, BY STATES (TONS OF 2240 LBS.)

ANTHRACITE PIG IRON.

States.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
Maryland..	19,560	19,220	19,950	14,142	5,368	8,472	5,575	13,595	20,536	18,866
Masschsts.	3,794	4,830	9,119	9,946	....	....	....	352	8,174	5,319
New Jers'y	92,734	91,376	80,492	57,204	22,633	47,240	63,346	86,525	151,829	153,278
New York.	242,268	238,829	266,453	227,620	154,942	190,963	207,086	197,256	328,141	287,814
Pennsylv'a	864,690	815,253	691,972	495,528	525,740	587,965	699,769	838,900	1,105,294	1,083,350
Virginia...	....	3,573	5,357	6,312	760	....	....	....	....	....
Total....	1,223,046	1,173,101	1,073,343	810,752	709,443	834,640	975,776	1,136,628	1,613,974	1,548,627
BITUMINOUS COAL AND COKE PIG IRON.										
Alabama	....	....	....	....	1,262	14,643	15,615	15,937	35,232	48,107
Colorado..	....	....	....	....	....	....	....	....	....	5,709
Georgia....	....	....	4,925	11,326	8,945	8,209	12,375	14,500	17,896	21,428
Indiana....	35,018	29,005	10,385	18,197	11,490	12,678	....	10,092	9,375	6,518
Illinois....	70,203	49,818	33,880	41,430	48,364	54,784	70,049	69,770	134,425	224,804
Kentucky.	24,729	24,706	21,948	23,265	15,600	27,324	29,691	32,133	32,619	26,067
Maryland..	10,785	4,700	6,436	1,563	....	69	....	2,033	4,809	....
Michigan...	11,948	8,509	6,859	11,607	11,339	6,250	....	....	....	....
Minnesota.	....	....	....	....	....	....	....	....	....	....
Missouri...	49,615	41,086	23,860	17,795	39,384	40,183	27,355	59,642	80,166	59,427
N. Carolina	....	....	....	....	....	....	....	....	....	....
New York.	....	....	....	....	....	....	....	....	....	5,982
Ohio.......	271,537	272,594	296,577	316,002	316,360	319,893	345,963	360,987	540,193	575,337
Pennsylv'a	346,438	384,494	354,594	331,608	355,076	415,356	472,806	564,553	715,908	826,361
Tennessee.	7,464	7,680	10,386	9,196	12,961	13,153	15,286	30,275	48,391	61,036
Virginia...	....	....	....	6,713	4,325	5,574	9,459	9,973	14,188	57,744
W.Virginia	17,719	18,840	23,869	21,587	36,486	30,049	44,876	63,036	59,905	58,222
Wisconsin.	33,274	31,495	19,498	32,739	22,325	....	20,000	51,870	48,147	48,494
Total....	878,730	873,127	813,137	846,028	883,937	918,165	1,063,475	1,284,801	1,741,254	2,025,256
CHARCOAL PIG IRON.										
Alabama..	11,171	19,895	29,342	22,418	20,818	22,180	21,422	28,563	33,693	39,483
California..	....	....	....	....	....	....	....	....	....	3,941
Connect c't	20,268	24,087	12,953	9,714	9,071	12,895	14,178	14,963	20,163	25,431
Georgia....	2,620	6,697	3,812	3,413	446	3,597	2,234	3,690	6,497	11,968
Indiana....	....	....	1,875	1,518	1,498	1,125	....	....	1,786	....
Kentucky.	35,446	37,695	32,718	19,892	15,369	15,182	15,114	11,371	18,905	14,971
Maine.....	....	696	1,481	1,827	2,680	1,750	1,062	1,107	3,195	3,928
Maryland.	25,934	27,067	22,324	18,884	12,378	15,529	15,876	17,619	29,508	24,666
Masschstts.	11,447	14,021	15,873	9,031	4,500	2,593	1,264	4,473	8,805	11,036
Michigan	77,536	101,764	115,151	90,897	73,640	67,157	63,261	90,659	137,878	167,003
Minnesota	....	....	....	....	....	....	....	....	3,142	6,644
Missouri.	40,704	35,300	43,833	35,523	21,529	25,500	15,054	15,926	14,079	38,608
New York	17,692	26,187	25,262	10,264	7,118	14,788	14,073	16,178	24,860	27,202
N. Carolina	958	1,278	1,196	714	357	290	....	....	....	714
Ohio.......	85,377	89,732	82,888	55,331	43,688	37,604	29,921	38,790	61,777	59,079
Oregon....	....	....	2,232	893	1,562	....	1,169	2,232	4,460	5,446
Pennsylv'a	40,209	40,943	36,588	30,795	20,624	26,160	26,214	32,049	38,727	46,346
Tennessee.	30,441	30,832	33,238	16,082	8,989	10,007	10,023	6,756	14,898	17,005
Texas......	553	250	903	....	380	468	....	357	2,232	2,678
Utah.......	....	....	178	134	158	....	....	....	....	....
Vermont..	1,786	2,768	3,080	2,143	491	188	522	558	1,607	2,497
Virginia...	19,147	20,065	20,939	13,746	6,563	5,529	5,654	6,877	12,538	16,998
Washingt'n	....	....	....	....	....	....	....	....	....	1,071
W.Virginia	848	1,746	3,036	982	268	1,116	352	178	2,897	1,071
Wisconsin.	24,816	34,708	25,881	22,754	23,452	19,830	24,560	28,076	38,315	42,603
Total....	446,953	515,731	514,783	366,955	275,579	283,788	291,963	320,422	479,962	570,389
TOTALS.										
Alabama..	11,171	19,895	29,342	22,418	22,082	36,823	37,037	44,500	68,925	87,590
California..	....	....	....	....	....	....	....	....	....	3,941
Colorado...	....	....	....	....	....	....	....	....	....	5,709
Connect'c't	20,268	24,087	12,953	9,714	9,071	12,395	14,178	14,963	20,163	25,431
Georgia....	2,620	6,697	8,737	14,739	9,391	11,806	14,609	18,190	24,393	33,396
Indiana....	35,018	29,005	12,260	19,715	12,988	13,803	....	10,092	11,161	6,518
Illinois....	70,203	49,818	33,880	41,430	48,364	54,784	70,049	69,770	134,425	224,804
Kentucky.	60,175	62,401	54,666	43,157	30,969	42,506	44,805	43,504	51,524	41,038
Maine......	....	696	1,481	1,827	2,680	1,750	1,062	1,107	3,195	3,928
Maryland..	56,277	49,987	78,710	34,589	17,746	24,070	21,451	33,247	54,853	43,532
Masschstts.	15,241	18,871	24,992	18,977	4,500	2,593	1,264	4,825	16,979	16,355
Michigan..	89,484	110,273	122,010	102,504	84,979	73,407	63,261	90,659	137,878	167,003
Minnesota.	....	....	....	....	....	....	....	....	3,142	6,644
Missouri...	90,319	76,386	67,693	53,318	60,913	65,683	42,409	75,566	94,245	98,035
New Jers'y	92,734	91,376	80,492	57,204	22,633	47,240	63,346	86,525	151,829	153,278
New York.	259,960	265,016	291,715	237,884	162,160	205,751	221,159	213,434	353,001	320,998
N. Carolina	958	1,278	1,196	714	357	290	....	....	....	714
Ohio.... ...	356,914	362,526	379,465	371,333	360,068	357,497	375,884	399,777	601,970	634,416
Oregon....	....	....	2,232	893	1,562	....	1,169	2,232	4,460	5,446
Pennsylv'a	1,251,337	1,240,690	1,083,154	857,931	901,440	1,029,781	1,198,789	1,435,502	1,859,929	1,956,057
Tennessee.	37,905	38,512	43,544	25,278	21,950	23,160	25,309	37,031	63,289	78,041
Texas......	553	250	903	....	380	468	....	357	2,232	2,678
Utah.......	....	....	178	134	58	....	....	....	....	....
Virginia...	19,147	23,638	26,296	26,771	11,646	11,103	15,113	16,850	26,726	74,742
Vermont..	1,786	2,768	3,080	2,143	491	188	522	558	1,607	2,497
W.Virginia	18,567	20,586	26,905	22,569	36,754	31,165	45,238	63,214	62,802	59,293
Washngt'n	....	....	....	....	....	....	....	....	....	1,071
Wisconsin.	58,092	66,203	45,379	55,493	45,777	19,830	44,560	79,948	86,465	91,097
Total....	2,548,729	2,560,959	2,401,263	2,023,735	1,868,959	2,066,593	2,301,214	2,741,851	3,835,190	4,144,252

PRODUCTION OF ALL KINDS OF PIG IRON, 1872-1892, BY STATES (TONS OF 2240 LBS.)

ANTHRACITE PIG IRON.

1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
23,434	21,492	8,289	....	10,273	16,493	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....
157,861	123,904	74,048	65,774	140,969	154,067	90,966	112,225	158,740	92,491	87,975
344.144	273.469	192,857	129,888	195,748	194,271	165,309	189,733	173,529	201,671	228,206
1,297,898	1,264,703	1,141,282	1,102,900	1,527,650	1,723,015	1,463,126	1,412,642	1,854,142	1,571,946	1,480,932
....	....	....	....	....	....	....	....	....	....	....
1,823.337	1,683,568	1,416,476	1,298,562	1,874,640	2,087,846	1,719,401	1,714,600	2,186,411	1,866,108	1,797,113
BITUMINOUS COAL AND COKE PIG IRON.										
51,093	102,750	116,264	133,808	180,133	176,374	317,289	608,034	718,383	717,687	835,840
21,177	22,036	14,140	4,894	9,331	22,581	18,640	2,391	21,061	18,116	32,441
23.995	28,856	29,500	24,220	41,099	36,559	34,908	22,577	23,266	34,120	....
8.928	8,885	2,292	5,924	14,875	11,797	13,625	8,785	14,641	7,729	7.700
321,792	212,196	292,471	292.838	448,031	504,868	517,238	536,638	701,107	669,201	949,450
44,068	36,293	33,187	29,327	43,287	31,882	46,193	31,903	44,515	41,456	53,349
....	1,138	2,620	6,131	9,947	3,125	1,700	15,680	132,799	114,148	89,371
....	....	....	....	....	....	....	....	....	...	....
....	....	....	....	....	....	....	....	....	1,226	14,071
52,961	61,771	25,433	26,449	48,523	87,403	56,684	47,777	59,451	14,828	28,968
....	....	....	....	....	....	....	....	515	2,750	2,598
....	....	....	....	....	46,871	46,495	58,626	140,252	103,045	65,851
571,648	570,648	484,137	478,560	796,368	854,460	966,032	1,065,272	1,216,940	1,015,220	1,202,926
844,317	1,057,239	967,867	1,069,732	1,397,852	1,556,188	1,727,988	2,306,367	2,544,869	2,369,890	2.701,063
89,278	88,093	103,385	116,094	153,363	182,250	192,929	218,242	219,400	245,986	249,892
54.997	121,454	127,372	134,941	134,090	148,445	169,608	216,418	286,508	292,057	341,118
65,375	78,927	49,313	61,613	88,052	73,492	85,053	105,268	129,438	86,283	154,793
27.136	11.187	24,110	4,428	33,418	76,781	41,322	69,794	135,001	103,056	92,835
2,176.765	2,401,473	2,272,091	2,388,959	3,398,369	3,813,076	4,235,704	5,313,772	6,388,146	5,836,798	6,822,266
CHARCOAL PIG IRON.										
49.590	51,237	53,078	69,261	73,312	85,020	84,041	98,595	98,528	77,985	79,456
8,881	4,756	1,926	....	1,562	....	....	....	....	....	....
21,734	17,836	12,655	15,625	17,312	19,411	19,325	21,556	20,135	21,810	17,107
13,898	11,647	8,585	5,176	409	....	268	2,029	5,919	15,738	9,950
....	....	....	....	....	....	....	....	....	....	....
15,326	12,483	7,038	4,203	5,681	5,537	4,512	6,058	3,345	3,388	3,199
3,660	3,928	....	393	4,518	3,925	4,977	4,643	1,072	....	....
25,247	21,256	13,500	9,314	7,028	13,798	14,019	14,540	15,021	9,251	9,760
9.229	9,607	4,378	775	7,253	9,924	11,828	6,920	4,938	8,990	7,946
187.674	154,629	154,316	127,787	170,298	190,663	190,403	191,389	230,768	213,146	184,421
7,255	7,143	....	....	....	....	....	....	....	....	....
48,506	30,457	28,177	19,451	18,015	36,386	25,265	29,178	30,326	14,400	28,052
27,425	22,928	20,971	13,109	12,839	23,653	17,820	17,039	16,025	10,395	16,338
1,026	....	388	1,598	1,964	3,250	2,143	2,588	2,325	467	310
52,369	36,177	22,214	16,087	14,429	16,557	19,521	20,060	23,390	19,793	18,987
6,027	6,250	3,250	3,421	....	....	2,240	8,416	10,987	9,296	7,628
44,620	34,209	20,674	10,846	14,935	10,634	13,528	14,242	16,318	10,553	11,810
33,581	31,517	16,791	27,833	24,466	41,271	46,295	44,844	48,225	45,752	50,189
1,178	2,126	4,588	1,645	2,902	3,913	5,881	4,057	9,700	18,662	8,613
51	....	....	....	....	....	....	....	....	....	....
1,080	....	....	....	....	....	....	....	....	....	....
23,333	15,070	13,240	11,292	5,418	8,443	6,638	8,006	6,270	3,235	1,729
....	2,068	482	1,658	2,537	1,416	3,654	9,259	....	....	....
....	....	....	....	....	....	....	....	....	....	....
49,440	35,145	23,051	17.529	25 439	42,433	62,285	71.849	84,853	94,103	82,126
623,130	510,469	409,302	357,003	410,317	516,234	534,633	575,268	628,145	576,964	537.621
TOTALS.										
100,683	153,987	169,342	203,069	253,445	261,394	401,330	706,629	816,911	795,672	915,296
881	4,756	1,926	....	1,562	....	....	....	....	....	....
21,177	22,036	14,140	4,894	9,331	22,581	18,640	2,391	21,061	18,116	32,441
21,734	17,836	12,655	15,625	17,312	19,411	19,325	22,556	20,135	21,810	17,107
37,893	40,503	38,085	29,396	41,508	36,559	35,176	24,606	29,185	49,858	9,950
8,928	8,885	2,292	5,924	14,875	11,797	13,625	8,785	14,641	7,729	7,700
321,792	212,196	292,471	292,838	448,031	504,868	517,238	536,638	701,107	669,201	949,450
59,394	48,776	40,225	33,530	48,968	37,419	50,705	37,961	47,860	44,844	56,548
3,660	3,928	....	393	4,518	3,925	4,977	4,643	1,072	....	....
48,681	43,886	24,409	15,445	27,248	33.416	15,719	30,220	147,820	123,399	99,131
9,229	9,607	4,378	775	7,253	9,924	11,828	6,920	4,938	8,990	7,946
187,674	154,629	154,316	127,787	170,298	190,663	190,403	191,389	230,768	213,146	148,421
7,255	7,143	....	....	....	....	....	....	....	1.226	14.071
101,467	92,228	53,610	45,900	66,538	123,789	81,949	76,955	89,777	29,228	57,020
157,861	123,904	74,048	65,774	140,969	154,067	90,966	112,225	158,740	92,491	87,975
371,569	296,397	213,828	142,997	208,587	264,796	229,624	265,398	329,806	315,111	310,395
1,026	....	388	1,598	1,964	3,250	2,143	2,588	2,840	3,217	2,908
624,017	606,825	506,351	494,647	810,797	871,017	985,553	1,085,332	1,240,330	1,035,013	1,221,913
6,027	6,250	3,250	3,421	....	....	2,240	8,416	10,987	9,296	7.628
2,186,835	2,356,151	2,129,823	2,183,478	2,940,437	3,289,837	3,204,632	3,733,251	4,415,329	3,952,389	4,193,805
122,859	119,610	120,176	143,927	177,829	223,521	239,224	263,086	267,625	291,738	300,081
1,178	2,126	4,588	1,645	2,902	3,913	5,881	4,057	9,700	18,662	81,613
51	....	....	....	....	....	....	....	....	....	....
78,330	136,524	140,612	146,233	139,508	156,888	176,246	224,424	292,778	295,292	342,847
1,080	....	....	....	....	....	....	....	....	....	....
65,375	78,927	49,313	61,613	88,052	73,492	85,053	105,268	129,438	86,283	154,793
....	2,068	482	1,658	2,537	1,416	3,654	9,259	....	....	....
76,576	46,332	47,161	21,957	58.857	119,213	103,607	141,643	219,854	197,160	174,961
4,623,232	4,595,510	4,097,869	4,044,524	5,683,326	6,417,156	6,489,738	7,603,640	[illegible],202,702	8,279,870	9,157,000

The world's production of pig-iron and steel in metric tons, from 1865 to the close of 1892, so far as can be ascertained, is given in the following table.

It is not claimed that in all particulars the table is accurate; but it is the first attempt that has been made to present this information in tabular form, and it is hoped that it will at least exhibit the relative progress that has been made during the last 27 years.

PRODUCTION OF PIG-IRON AND STEEL IN THE PRINCIPAL COUNTRIES, 1865–92.

Metric Tons of 2204 Lbs.

From 1865 to 1885 the production of steel in all other countries is taken at 25,000 tons. From 1885 to 1892, at 225,000 tons.

	Great Britain.		United States.		Germany.		France.		Belgium.		Austro-Hungary.		Sweden.		Russia.		All other Countries	The World.	
	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Steel.	Pig-iron.	Pig-iron.	Steel.
1865..	4,897,971	225,000	843,410	13,848	882,546	97,752	989,972	41,559	470,767	2,800	300,000	5,000	240,000	5,000	275,000	3,871	200,000	9,099,666	419,830
1866..	4,697,636	235,000	1,222,480	17,216	948,507	114,434	1,260,348	40,574	450,000	3,820	319,709	12,000	255,000	7,000	290,000	3,932	211,800	9,655,480	458,976
1867..	4,828,627	245,000	1,326,450	19,963	1,113,606	122,591	1,229,044	47,597	423,069	4,500	361,038	15,000	260,000	9,000	300,000	6,271	220,272	10,062,106	494,922
1868..	5,051,220	260,000	1,454,272	27,223	1,264,347	122,837	1,235,308	80,564	435,754	6,000	425,071	20,000	270,000	13,500	335,000	9,327	234,483	10,705,455	564,451
1869..	5,534,522	275,000	1,739,232	31,760	1,413,029	161,319	1,380,965	110,224	534,319	7,500	450,567	30,000	285,065	13,150	350,000	7,200	262,069	11,949,768	661,153
1870..	6,060,720	286,797	1,692,378	68,057	1,391,124	169,951	1,178,114	83,788	565,234	8,900	452,244	40,000	293,438	12,193	359,989	8,647	266,669	12,259,910	703,333
1871..	6,735,202	410,585	1,730,800	74,710	1,563,682	250,947	859,641	79,811	609,239	12,000	476,627	52,000	293,277	8,551	353,710	7,132	280,704	12,902,873	924,736
1872..	6,851,822	497,987	2,590,360	145,289	1,988,394	312,247	1,217,838	130,088	655,565	16,000	531,850	67,500	334,788	15,876	399,273	8,254	323,889	14,893,789	1,218,241
1873..	6,673,484	588,437	2,602,750	202,075	2,240,574	302,647	1,366,971	155,568	607,373	22,000	594,980	25,000	339,685	15,685	378,387	8,807	337,971	15,142,175	1,345,219
1874..	6,089,067	643,317	2,440,470	219,250	1,906,262	354,256	1,423,308	216,072	532,790	38,000	545,742	37,000	332,154	21,312	374,355	9,511	308,581	13,952,729	1,563,718
1875..	6,469,219	723,605	2,056,750	396,165	2,029,389	370,655	1,416,228	258,780	540,473	47,200	504,347	45,000	343,551	19,367	426,896	14,252	315,369	14,102,222	1,900,024
1876..	6,662,859	851,659	1,899,480	541,900	1,846,345	390,434	1,453,112	232,247	490,508	75,000	450,933	70,000	344,834	21,002	420,000	19,749	310,324	13,878,395	2,226,991
1877..	6,716,385	904,507	2,100,380	578,921	1,932,725	495,000	1,400,000	238,660	470,488	84,000	409,000	97,470	336,370	16,995	410,000	48,793	314,978	14,090,326	2,488,686
1878..	6,485,062	1,117,930	2,338,790	743,931	2,147,641	570,328	1,417,072	313,090	493,544	155,000	424,249	129,478	333,496	19,336	409,633	104,766	320,962	14,370,449	3,178,859
1879..	6,093,060	1,029,522	2,786,650	950,550	2,226,587	500,900	1,344,759	327,621	448,371	155,000	404,160	125,000	342,547	20,400	429,865	233,471	321,283	14,397,282	3,367,464
1880..	7,875,545	1,320,561	3,897,840	1,267,700	2,729,037	660,591	1,725,293	388,894	595,704	158,000	465,518	129,007	405,765	28,597	441,285	295,568	411,241	18,547,228	4,273,918
1881..	8,513,915	1,808,728	4,211,980	1,614,258	2,914,009	897,425	1,899,861	418,094	624,736	160,000	543,000	130,000	435,428	38,252	462,027	285,082	443,241	20,038,273	5,376,839
1882..	8,631,727	2,245,666	4,698,790	1,765,070	3,380,806	1,074,806	2,039,067	458,238	727,000	200,000	611,681	150,000	398,945	41,000	498,400	225,140	474,711	21,461,127	6,184,920
1883..	8,628,614	2,041,624	4,670,570	1,700,865	3,469,719	1,060,591	2,067,387	521,820	770,659	179,489	710,037	271,733	422,627	45,000	490,000	200,000	477,559	21,707,172	6,046,122
1884..	7,651,688	1,891,985	4,164,800	1,576,210	3,572,155	1,200,000	1,855,247	509,516	750,812	185,916	771,502	225,752	430,534	74,241	500,000	300,000	444,130	20,140,868	5,988,620
1885..	7,368,842	2,020,450	4,110,600	1,739,883	3,751,775	1,202,090	1,629,051	553,839	714,677	125,461	805,631	278,803	464,737	80,550	510,000	250,000	436,580	19,791,893	6,276,076
1886..	7,124,012	2,403,214	5,776,168	2,604,355	3,528,658	1,360,620	1,507,850	466,913	701,277	164,085	726,835	256,023	442,457	77,118	519,865	234,317	458,409	20,785,531	7,791,645
1887..	7,682,738	3,196,778	6,521,973	3,393,640	3,907,364	1,685,406	1,567,622	493,294	754,481	206,350	703,530	276,670	456,625	110,100	612,938	222,025	478,120	21,685,391	9,809,263
1888..	8,129,047	3,774,670	6,595,735	2,933,260	4,337,421	1,862,000	1,683,349	517,294	826,850	231,000	790,227	355,038	457,052	114,537	666,922	228,289	529,278	24,015,908	10,241,088
1889.	8,458,486	3,605,346	7,871,509	3,441,033	4,524,558	2,022,472	1,733,964	529,302	832,226	254,397	816,156	398,156	420,665	135,227	798,679	263,719	573,737	26,029,980	10,874,652
1890..	8,033,052	3,637,381	9,353,020	4,346,932	4,637,239	2,161,821	1,970,160	566,197	787,236	239,266	925,308	499,600	456,102	160,026	860,000	260,000	609,595	27,630,712	12,096,223
1891..	7,526,782	3,207,994	8,415,110	3,968,010	4,452,019	2,352,074	1,919,185	725,290	688,056	243,729	950,000	500,000	490,912	172,774	875,000	270,000	571,595	25,889,659	11,664,871
1892*.	6,724,970	2,966,522	9,269,382	4,300,000	5,400,000	2,600,000	2,200,000	800,000	725,000	250,000	950,000	525,000	475,000	170,000	870,000	275,000	584,328	27,185,680	12,111,522

* The returns for the last half of 1892 are estimated, as well as those of the last three years for Russia.

Cost.—The cost of making pig-iron in the northern and southern districts of the United States, in Great Britain, and on the Continent of Europe has been investigated by the United States Labor Bureau under the Hon. Carroll D. Wright, Commissioner. The period covered was between 1887 and 1890. The results are given in the following tables, which have been collected and arranged from Mr. Wright's report. In summing up the cost of producing a ton of pig-iron, as given by Mr. Wright, we have omitted what he terms "certain theoretical elements," as they are not of sufficient moment to affect the general result. From the tables it appears that the total cost of one ton of run-of-furnace pig-iron, as reported by 26 establishments in the northern district of the United States, is $13.94, as against $10.75 in 24 establishments in the southern district—a difference of $3.19 per ton. On the Continent of Europe one establishment gives $11.03.

The comparative average cost of one ton of run-of-furnace pig-iron in the two districts is shown as follows:

	Northern.	Southern.
Ore	$6.96	$3.47
Cinder, scrap, etc.	.58	.01
Limestone	.50	.47
Coke	3.33	4.46
Coal	.37	0.00
Total materials	11.74	8.41
Labor	$1.47	$1.53
Officials and clerks	0.18	0.16
Supplies and repairs	.51	0.61
Taxes	.04	0.04
Total	$13.94	$10.75

The chief advantage of the southern district is thus seen to be in the reduced cost of ore, while in coke it is at a disadvantage of $1.14 per ton. So far as labor is concerned, it costs 5c. per ton more in the southern than in the northern district, and supplies and repairs 10c. per ton more. The opportunity for comparing the cost of charcoal iron in the two districts is not afforded by these tables, as a report was received from only one establishment in the southern district. This one, however, reported the cost of hot-blast charcoal as $10.28, while the cost in the northern district varied from $14.70 to $23.16. It is not at all likely that the average cost of hot-blast charcoal iron anywhere in the country is below $14. The average cost of gray forge iron in the northern district of the United States is given as $13.50, in Great Britain as $8.03, and on the Continent as $9.06. No gray forge or Bessemer was reported from the southern district of the United States.

The average cost of Bessemer iron in the northern district of the United States was $15.37; in Great Britain, $10.33; and on the Continent, $11.74. The average cost of No. 1 foundry iron in the northern district was $13.86, and on the Continent $7.74, excluding taxes. Spiegeleisen on the Continent cost $15.07; basic iron, $9.63; and in Great Britain, $10.89.

In the tables the numbers 1 to 8 represent charcoal iron; 9 to 39, Bessemer; 40, spiegeleisen; 41 to 51, foundry; 52 to 64, gray forge; 65 to 115, run-of-furnace; and 116 to 118, basic, or Thomas, iron.

Through the kindness of the Thomas Iron Company, Hokendauqua, Pa., we are enabled to extend the very valuable table published in the *Engineering and Mining Journal* in 1874, showing the itemized cost of producing pig-iron at this establishment from its commencement.

PIG IRON PRODUCTION.

CONDITIONS OF OUTPUT, AND MATERIALS HANDLED PER TON OF 2,240 LBS.

[Establishments numbers 1 to 7, 9 to 32, 41, 42, 46 to 59, and 65 to 90 are in the northern district of the United States; numbers 8 and 91 to 114 are in the southern district of the United States; numbers 33 to 35, 40, 43 to 45, 60, 64, 115, 117 and 118 are on the continent of Europe; and numbers 36 to 39, 61 to 63 and 116 are in Great Britain.]

ALL TONS OF 2,240 LBS.

Establishment No.	Furnaces.			Days worked.	Output, tons.		Tons to 1 ton pig iron.					
	No.	Diam. bosh ft.	Height stack ft.		Per day per furnace.	Total	Ore	Cinder, Scrap, etc.	Lime-stone.	Coke.	Coal.	Total
1	1	11.0	48	150	19	2,890	2.46	...	.89n	....	.97p	4.32
2	1	10.0	36	344	73	24,945	1.61	...	.07	....	.90p	2.58
3	1	11.0	50	196	60	11,779	1.80	...	.16	....	.95p	2.91
4	1	11.0	55	305	44	13,514	1.88	...	.24	....	.99p	3.11
5	1	10.0	32	241	12	3,000	2.55	...	.56	....	1.33p	4.44
6	1	10.2	36	248	10	2,500	2.94	...	.44	....	2.07p	5.45
7	1	8.0	30	317	5	1,582	2.49	...	.50	....	1.29p	4.28
8	1	11.5	55	353	41	14,398	2.25	...	.23	....	.94p	3.42
9	1	17.6	80	365	140h	18,614 i	1.63	.15	.40	1.10	.....	3.28
10	1	18.0	80	336	153	51,506	1.65	.03	.35	1.07	.....	3.10
11	1	17.0	65	297	71	21,074	1.61	.06	.33	.97	.30	3.27
12	1	16.0	75	171	148	25,393	1.38	.11	.32	.87	.....	2.68
13	1	13.5	65	338	73	24,741	1.47	.04	.39	1.19	.....	3.09
14	2	a	b	344	123	84,620	1.72	...	.49	1.27	.....	3.48
15	1	15.0	75	288	114	32,879	1.59	.13	.60	1.12	.05	3.49
16	2	20.0	c	205	178	72,884	1.64	.01	.34	.98	.....	2.97
17	1	15.7	70	310	97	30,000	1.60	...	.53	1.10	.08	3.31
18	1	15.0	75	216	119	25,715	1.51	.14	.58	1.45	.....	3.68
19	1	17.0	80	182	140	25,450	1.64	.01	.42	.99	.14	3.20
20	1	17.0	70	365	120	43,800	1.82	...	.48	.44	.50q	3.24
21	1	20.0	75	91	236	21,150	1.64	...	.43	.86	.....	2.93
22	1	17.0	70	184	120	22,080	1.82	...	.48	.44	.50q	3.24
23	1	14.0	65	365	83	30,392	1.62	...	.30	.85	.13	2.90
24	1	15.0	75	214	113	24,189	1.64	...	.32	1.08	.06	3.10
25	1	12.0	65	348	78	27,132	1.66	...	.33	1.00	.14	3.13
26	1	15.0	70	309	102	31,474	1.63	...	.34	1.11	.20	3.28
27	2	d	e	333	63	41,634	1.62	...	.46	1.38	.02	3.48
28	1	16.0	75	365	120	43,800	1.72	.04	.81	1.19	.....	3.76
29	1	16.0	75	226	145	32,845	1.44	.16	.61	1.53	.....	3.74
30	1	18.0	65	180	118	21,194	1.59	.02	.45	1.21	.....	3.27
31	1	18.0	65	173	117	20,259	1.56	.02	.46	1.27	.....	3.31
32	1	16.0	75	191	129	24,647	1.41	.17	.56	1.21	.03	3.38
33	4	19.1	60	366	73	107,278	1.86r	r	.51	1.14	.....	3.51
34	3	19.1	60	28	35 j	1,508 k	1.90r	r	.57	1.09	.....	3.56
35	2	19.7	66	365	117	85,626	1.90	..	.45	1.04	.....	3.49
36	2	20.0	60	182	87	31,714	1.85	.03	.32	1.19	.....	3.36
37	4	f	60	182	69 l	45,408m	1.76	.11	.32	1.21	.....	3.40
38	3	17.5	g	182	62	34,093	1.70s	.15	.41	1.35	.....	3.61
39	2	19.0	75	363	87	62,929	1.88	...	.33	.95	.01	3.17
40	1	13.1	56	31	34	1,067	2.21	...	.55	1.08	....	3.84
41	1	14.0	65	167	50	8,296	2.44	...	.58	.89	.65q	4.56
42	1	15.0	70	365	81	29,390	2.37	...	.69	.92	.42q	4.40
43	t	t	t	t	t	t	t	t	t	t	t	t
44	3	19.1	60	28	35	1,392 u	2.42r	r	.40	1.01	.....	3.83
45	t	t	t	t	t	t	t	t	t	t	t	t
46	1	16.0	60	365	44	15,954	1.67	.03	.56	.10	1.23q	3.59
47	1	15.0	65	234	49	11,467	2.14	...	.40	1.09	.40q	4.03
48	1	17.0	63	311	76	23,720	1.52	.22	.66	1.24	.21	3.85
49	1	16.0	65	273	66	17,757	1.56	.17	.57	1.09	.27	3.66
50	1	17.7	80	365	140	32,417 v	1.59	.15	.40	1.11	.....	3.25
51	1	17.0	80	233	107	24,867	1.58	.29	.33	1.17	.....	3.37
52	2	16.0	70	230	114	52,494	1.16	.41	.68	1.15	.....	3.40
53	1	16.0	75	365	156	57,100	1.09	.61	.55	1.16	.01	3.42
54	2	15.5	55	181	63	22,931	1.50	.49	.57	.30	1.08q	3.94
55	1	15.5	70	180	123	22,060	1.64	r	.71	1.39	.....	3.74
56	1	14.5	65	182	78	14,214	1.93	.21	.77	1.50	.....	4.41
57	1	19.0	80	1	195	195	1.58	...	.75	.89	.....	3.22
58	1	20.0	75	62	181	11,222	.84	.82	.82	.88	.....	3.36
59	1	13.0	54	365	42	15,415	1.16	.48	.63	1.23	.09q	3.59

(a) One 17 ft. and one 15.5 ft. (b) One 80 ft. and one 70 ft. (c) One 75 ft. and one 80 ft. (d) One 12.7 ft. and one 13.7 ft. (e) One 65 ft. and one 70 ft. (f) One 17.5 ft. and three 16 ft. (g) One 66 ft. and two 60 ft. (h) Including prod. of foundry iron. (i) Including 32,417 tons foundry iron. (j) Including prod. of No. 2 F. (k) Including 1,392 tons No. 2 F. (l) Including gray forge. (m) Including 4,843 tons G. F. (n) Oyster shells. (p) Charcoal. (q) Anthracite. (r) The quantity and cost of cinder, scrap, etc., are inseparably combined with those for ore. (s) Including manganese. (t) Not reported. (u) Including also

PIG IRON PRODUCTION.

CONDITIONS OF OUTPUT, AND MATERIALS HANDLED PER TON OF 2,240 LBS.

[Establishments numbers 1 to 7, 9 to 32, 41, 42, 46 to 59, and 65 to 90 are in the northern district of the United States; numbers 8 and 91 to 114 are in the southern district of the United States; numbers 33 to 35, 40, 43 to 45, 60, 64, 115, 117 and 118 are on the continent of Europe; and numbers 36 to 39, 61 to 63 and 116 are in Great Britain.]

ALL TONS OF 2,240 LBS.

Establishment No.	Furnaces.			Days worked.	Output, tons.		Tons to 1 ton pig iron.					
	No.	Diam. bosh ft.	Height stack ft.		Per day per furnace.	Total	Ore	Cinder, Scrap, etc.	Lime-stone.	Coke.	Coal.	Total
60	2	t	t	365	93	67,839	2.10	.68	.21	1.15	.02	4.16
61	4	a[1]	60	182	69	4,843 w	1.19	.66	.34	1.01	......	3.20
62	1	20.0	75	365	82	21,873 y	2.97	...	.50	1 12	.01	4.60
63	1	20.0	75	365	82	7,980 z	3.20	...	.52	1.12	.01	4.85
64	1	t	t	22	57	1,258	3.43	.11	....	1.15	......	4.69
65	1	12 0	52	252	34	8,489	1.53	.83	.74	....	2.31	5.41
66	1	16.0	75	340	118	39,985	1.68	...	.40	1 19	.01	3.28
67	1	16 0	75	304	107	32,633	1.33	.38	.45	1 11	......	3.27
68	1	15.5	72	92	122	11,232	1.64	.06	.34	1.25	.09	3.38
69	2	16.0	75	182	106	38,415	1.62	.14	.54	1 34	......	3.64
70	1	14.5	57	365	44	16,050	1.92	...	.33	1.32	.05	3.62
71	1	16.0	75	361	156	56,316	1.66	...	.47	.91	......	3.04
72	1	18.5	77	366	100	36,479	1.29	.47	.98	1.37	......	4.11
73	1	15 5	59	350	42	17,724	1.72	.25	.85	.38	1.04q	4.24
74	1	15.5	56	366	89	32,739	1.85	...	.72	46	.76q	3.79
75	1	16.0	60	366	94	34,543	1.21	.46	.72	1 26	......	3.65
76	1	14.0	63	357	91	32,660	1.23	.38	.47	1 17	.....	3.25
77	1	15.5	72	309	84	26,016	1.27	.44	.57	1 11	.20	3.59
78	1	13.0	50	31	34	1,051	1.08	89	.91	.25	1.26q	4.39
79	1	13.5	60	30	54	1,625	1.89	.30	95	.82	.53q	4.49
80	2	17.0	65	31	45	2,769	2.58	...	2 05	1 48	......	6.11
81	1	16.5	65	296	62	18,214	1.56	.50	1.00	1 83	......	4.89
82	1	12.5	61	92	25	2,343	1.68	.52	1 56	2 05	......	5.81
83	1	12.0	60	92	27	2,447	1.35	.51	1.22	1 65	......	4.73
84	1	13.5	60	120	49	5,877	1.88	.30	.94	.89	.46q	4.47
85	1	11.5	43	92	15	1,385	2.87	.28	1 44	.04	1.40q	6.03
86	1	14.0	60	184	96	17,689	1.64	.25	.50	1.10	......	3.49
87	1	12.3	60	124	74	9,182	1.54	.18	.62	1.18	......	3.52
88	1	14 0	70	306	80	24,401	2.23	.09	1 58	1 24	......	5.14
89	1	15.0	65	334	111	37,240	1.67	...	.32	1 09	......	3.08
90	2	17.0	66	167	119	39,873	1.49	.19	.36	1.03	......	3.07
91	2	17.0	75	283	69	39,028	2.41	01	.45	1 82	......	4.69
92	2	b[1]	c[1]	286	61	35,036	2.35	...	.73	1.56	......	4.64
93	1	16.0	75	78	85	6,591	2.30	...	.78	1.25	.....	4.33
94	1	18.0	75	344	102	35,158	2.12	...	.60	1.15	......	3.87
95	1	13.7	65	371	52	19,323	2.00	.10	.92	1.79	......	4.81
96	1	17.5	65	290	81	23,486	2.16	.09	.76	1.33	......	4 34
97	1	16 0	75	106	98	10,353	2.11	...	.37	1.35	......	3.83
98	1	16.0	75	83	87	7,200	2.30	...	.83	1 47	......	4.60
99	4	20.0	80	31	102	12,595	2.52	...	.45	1.51	......	4.48
100	2	d[1]	e[1]	365	86	62,561	2.26	...	.52	1 64	......	4.42
101	2	17.0	75	323	72	46,770	2.29	.01	.59	1 77	......	4.66
102	1	17.0	63	31	89	2,774	2.72	...	.58	1.84	......	5.14
103	1	16.0	69	365	95	34,506	1.97	.12	.74	1.26	......	4.09
104	1	1.30	60	30	64	1,921	1.96	...	.96	1 55	......	4.47
105	2	f[1]	65	30	47	2,792	2.59	..	.43	1.55	.18	4.75
106	1	16.0	69	30	113	3,400	1.81	.11	.77	1 12	......	3 81
107	2	18.0	75	365	100	73,000	1.97	...	.65	1.46	......	4.08
108	2	20.0	70	365	84	61,133	2.95	...	....	1.51	...	4.46
109	1	16.0	70	315	105	32,921	2.53	...	1.12	1.33	......	4.98
110	2	g[1]	60	364	42	30,338	2.09	...	.79	1.03	......	3.91
111	1	12.5	61	328	37	12,092	2.37	...	1 29	1.42	......	5.08
112	1	17.0	75	365	109	39,947	2.32	...	1 00	1.11	......	4.43
113	1	18.5	80	361	119	42,948	2.25	...	1 01	1 22	......	4.48
114	1	11 0	60	338	35	11,855	2.19	...	.92	1.46	......	4.57
115	2	h[1]	i[1]	365	46	33,685	2.08	.67	1.06	1.50	......	5.31
116	t	t	t	91	t	13,200	2.06r	t	.55	1 31	t	3.92
117	t	t	t	t	t	t	t	t	t	t	t	....
118	1	t	t	31	55	1,690	3.51	...	....	1.20	......	4.71

1,508 tons Bessemer. (v) Including also 18,614 tons Bessemer. (w) Including also 45,408 tons Bessemer. (y) Including also 7,980 tons ordinary G. F. (z) Including 21,873 tons special G. F. (a[1]) One 17.5 ft. and three 16 ft. (b[1]) One 16.5 ft. and one 17.7 ft. (c[1]) One 63 ft. and one 75 ft. (d[1]) One 16 ft. and one 17 ft (e[1]) One 65 ft. and one 70 ft. (f[1]) One 14 ft. and one 15 ft. (g[1]) One 11 ft. and one 14 ft. (h[1]) One 18.5 ft. and 19.7 ft. (i[1]) One 50 ft. and one 62 ft.

COST OF PRODUCTION

ELEMENTS OF COST

[Establishments numbers 1 to 7, 9 to 32, 41, 42, 46 to 59, and 65 to 90 are in the northern district of the United States; numbers 8, and 91 to 114 are in the southern district of the United States; numbers 33 to

Establishment.	Materials. Ore.	Materials. Cinder Scrap, etc.	Materials. Limestone.	Materials. Coke.	Materials. Coal.	Materials. Total.	Labor.	Officials and Clerks.	Supplies and Repairs.	Taxes.	Total of all Costs.	Transportation cost per ton of Pig Iron. Ore.	Transportation cost per ton of Pig Iron. Limestone.	Transportation cost per ton of Pig Iron. Coke.	Transportation cost per ton of Pig Iron. Coal.	Transportation cost per ton of Pig Iron. Total.
	$	$	cts.	$	$	$	$	cts.	$	cts.	$	$	cts.	$	$	$
1	10.32	......	10 a	......	7.30 b	17.72 c	3.58 c	76	1.00	8	23.16	j	j	......	p	......
2	4.00	......	17	......	9.04 d	13.22	1.19	26	0.48	4	15.20	0.40	8	......	1.05	1.53
3	6.93	......	15	......	5.26 d	12.35	1.23	26	0.50	10	14.45	1.94	9	......	q	2.03
4	5.30	......	16	......	4.72 d	10.19	3.09	75	0.57	9	14.70	0.94	7	......	p	......
5	5.22	......	28	......	9.00 d	14.51	1.93	53	1.33	46	18.76	1.27	22	......	2.67	4.16
6	8.53	......	33	......	11.58 d	20.45	2.93	88	0.92	6	25.24	1.79	26	......	1.03	3.08
7	9.96	......	62	......	11.63 d	22.21	1.60	50	0.22	12	24.67	1.32	30	......	p	......
8	1.98	......	23	......	5.54 d	7.75	1.46	52	0.49	3	10.27	0.45	12	......	.84	1.41
9	7.79	0.32	42	4.45	....	12.99	1.23	13	0.16	3	14.55	1.22	18	3.04	......	4.44
10	8.24	0.06	46	5.16	....	13.93	1.51	23	0.37	11	16.17	j	24	3.59	......	......
11	8.55	0.17	28	3.06	0.44	12.53	1.57	12	0.24	1	14.47	1.21	14	1.76	.07	3.18
12	8.40	0.69	32	2.56	....	11.99	0.97	13	0.40	8	13.58	3.79	19	1.18	......	5.16
13	8.91	0.13	40	3.21	....	12.67	1.14	9	0.17	6	14.15	1.54	23	1.61	......	3.38
14	9.41	......	38	3.42	....	13.22	1.15	17	0.50	2	15.07	4.30	14	1.71	......	6.15
15	8.98	0.33	62	3.35	0.08	13.38	1.49	13	0.48	3	15.53	3.99	42	1.52	.01	5.94
16	9.41	0.05	34	3.58	....	13.39	1.44	13	0.25	5	15.28	3.04	22	1.82	......	5.08
17	11.20	......	40	3.70	0.10	15.40	1.50	31	0.55	1	17.78	3.16	21	1.48	.05	4.90
18	9.66	0.33	62	3.51	....	14.13	1.64	19	0.79	5	16.81	3.78	34	1.96	......	6.08
19	9.77	0.07	43	2.98	0.16	13.42	1.66	25	0.41	5	15.82	1.73	25	1.34	.04	3.36
20	9.00	......	49	1.75	1.72 e	12.97	1.25	9	0.50	2	14.84	j	j	1.06	.62e	......
21	10.33	......	43	1.89	....	12.65	1.15	15	0.51	4	14.51	4.52	21	0.41	.....	5.14
22	10.01	......	54	2.17	1.75 e	14.48	1.25	9	0.50	2	16.34	j	j	1.06	[illegible]2e	......
23	8.70	......	24	2.38	0.32	11.66	1.36	18	0.20	1	13.43	3.20	10	1.15	.03	4.48
24	8.94	......	24	2.98	0.15	12.52	1.15	8	0.31	2	13.90	3.11	12	1.46	.04	4.73
25	8.38	......	24	2.83	0.23	11.70	1.43	14	0.57	1	13.88	3.28	9	1.35	.08	4.80
26	9.05	......	25	3.11	0.28	12.70	1.40	12	0.46	1	14.71	3.23	10	1.49	.12	4.94
27	9.27	......	37	4.03	0.02	13.70	1.53	32	0.92	1	16.50	2.87	18	1.87	.01	4.93
28	10.43	0.01	66	2.81	....	13.93	1.15	4	1.37	f	16.50	5.61	33	1.19	.....	7.13
29	9.25	0.32	66	3.95	....	14.20	1.83	19	0.99	2	17.24	3.60	36	2.06	......	6.02
30	9.12	0.08	48	3.28	....	12.97	1.33	8	0.41	9	14.90	3.66	27	1.64	......	5.57
31	8.80	0.08	51	3.62	....	13.03	1.37	8	0.42	6	14.98	3.59	27	1.71	......	5.57
32	8.16	0.35	60	3.43	0.04	12.59	1.89	11	0.90	3	15.53	3.53	34	1.64	.01	5.52
33	6.42	g	21	2.91	....	9.55	0.41 h	i	0.41	j	10.39k	r g	6	0.04	......	n[1]
34	6.80	g	26	3.18	....	10.25	0.44 h	i	0.52	j	11.22k	s	6	0.04	......	o[1]
35	8.75	......	26	3.20	....	12.22	0.91	l	0.27	l	13.43m	t	22	u	......	p[1]
36	6.13	0.14	17	2.77	....	9.23	0.60	2	0.42	1	10.29	3.37	j	u	......	......
37	5.79	0.22	17	2.77	....	8.95	0.60	1	0.58	1	10.16	3.20	j	u	......	......
38	6.06 n	0.56	20	2.47	....	9.30	0.74	14	0.51	1	10.72	j	j	j	......	......
39	6.38	......	26	2.55	0.03	9.23	0.71	5	0.21	3	10.24	j	j	j	j	......
40	8.40	......	56	5.24	....	14.21	0.71	5	0.04	2	15.07	0.19	25	1.00	......	1.45
41	4.61	......	46	3.90	2.27 e	11.26	2.06	46	0.30	2	14.12	0.48	26	2.58	1.04e	4.36
42	3.68	......	51	4.99	1.52 e	10.73	1.98	23	0.62	2	13.59	0.47	24	2.69	.68e	4.08
43	3.63	g	18	2.97	....	6.78	0.47 h	i	0.48	j	7.73 k	j	j	j	j	......
44	4.02	g	18	2.97	....	7.18	0.46 h	i	0.48	j	8.13 k	v	3	0.04	......	......
45	4.61	g	18	2.97	....	7.66	0.47 h	i	0.48	j	8.71 k	j	j	j	j	......
46	5.80	0.23	60	0.55	5.06 e	12.26	2.13	7	0.62	16	15.25	w	25	0.28	j e	......
47	5.75	......	40	4.28	1.42 e	11.88	1.73	44	0.49	4	14.60	2.67	20	1.91	.81e	5.59
48	6.80	0.66	40	3.89	0.39	12.15	1.46	10	0.26	o	13.99 k	1.06	6	2.23	.16	3.51
49	5.80	0.42	57	3.66	0.61	11.09	1.67	14	0.34	2	13.29	x	28	1.58	.08	......
50	5.41	0.32	42	4.45	... .	10.61	1.23	13	0.16	3	12.17	1.19	18	3.05	......	4.42
51	6.48	0.68	44	5.61	....	13.23	1.70	12	0.19	6	15.32	y	15	3.23	......	q[1]
52	6.40	0.99	59	3.30	....	11.29	0.98	5	0.69	3	13.06	2.90	26	1.55	......	4.71
53	5.51	1.73	41	3.16	0.01	10.84	1.31	11	0.29	1	12.56	2.17	22	1.57	.007	3.96
54	8.83	0.77	48	1.35	3.25 e	14.71	1.30	27	0.64	2	16.95	j	23	0.63	1.03e	......
55	7.22	g	67	2.70	....	10.60	1.45	14	0.58	4	12.83	4.53g	35	0.97	......	5.82
56	7.23	0.39	58	3.53	....	11.74	1.26	45	0.50	3	14.00	z	27	1.05	......	......
57	9.11	......	83	2.25	....	12.19	1.27	6	0.51	3	14.07	4.35	52	0.002	......	4.87
58	5.01	2.47	82	1.92	....	10.24	1.52	19	0.66	5	12.68	2.31	41	0.52	...	3.24
59	4.85	1.56	52	3.79	0.31 e	11.06	2.19	13	0.96	2	14.37	3.02	25	1.66	.06e	4.99

(a) Oyster shells. (b) Represents the cost of wood entering into the charcoal. (c) The labor cost of converting the wood into charcoal is inseparably combined with furnace labor. (d) Charcoal. (e) Anthracite coal. (f) The expenditures for taxes are inseparably combined with those for supplies and repairs. The cost of repairs for this establishment was unusually high during the period covered by this investigation. (g) The expenditures for cinders, scrap, etc., are inseparably combined with those for ore. (h) Furnace labor proper only. (i) The expenditures for ordinary labor and officials are inseparably combined with those for supplies and repairs. (j) Not reported. (k) Not including taxes. (l) The expenditures for taxes and insurance are inseparably combined with those for supplies and repairs. (m) Including insurance. (n) Including manganese. (o) Taxes not paid by lessee of furnace. (p) Facts relative to charcoal not reported. (q) Charcoal kilns located at works. (r) From \$2.79 to \$3.81. (s) From \$0.58 to \$2.75. (t) From \$4.12 to \$4.84. (u) Coke ovens located at works. (v) From \$0.75 to \$3.51. (w) Part of the ore is brought 64 miles at a cost of \$1.55 per ton, and part 221 miles at a cost of \$2.00 per ton. (x) Part of the ore is brought 20 miles at a cost of 35 cents per ton, and part 900 miles at a cost of \$2.65 per ton. (y) From \$1.10 to \$3.55. (z) Part of the ore is brought 35 miles at a cost of 35 cents per ton, and part 200 miles at a cost of \$1.05 per ton. [a[1]] From the total of \$12.07 subtract \$1.04

OF PIG IRON.

IN 1 TON (2,240 LBS.)

35, 40, 43 to 45, 60, 64, 115, 117 and 118 are on the Continent of Europe; and numbers 36 to 39, 61 to 63, and 116 are in Great Britain.]

Establishment.	Materials.						Labor.	Officials and Clerks.	Supplies and Repairs.	Taxes.	Total of all Costs.	Transportation cost per ton of Pig Iron				
	Ore.	Cinder, scrap, etc.	Limestone.	Coke.	Coal.	Total.						Ore.	Lime-Stone.	Coke.	Coal.	Total.
	$	$	cts	$	$	$	$	cts.	cts.	cts.	$	$	cts.	$	cts.	$
60	3 30	0.83	6	4.07	0.04	8.33	0 42	6	22	2	9.07	2.25	2	0.02	0.4	2.29
61	3.69	0.30	18	2.27	....	6.45	0.61	1	57	1	7.67	2.16	j	u	......	......
62	3.77	......	38	2.98	0.03	7.16	0.71	5	21	3	8.17	j	j	j	j	......
63	3.42	......	40	2.98	0.03	6.84	0.71	5	21	3	7.85	j	j	j	j	......
64	1.84	0.17	....	5.32	....	7.83	0.76	20	34	9	8.63	f¹	....	g¹	......	......
65	5.57	1.08	66	......	3.79	11.12	1.25	44	32	7	13.20	1.30	29	......	76	2.35
66	7 52	......	26	3.33	0.02	11.14	1.16	20	28	1	12.82	4.21	10	1.61	0.6	5.928
67	6.67	1.00	45	3.36	....	11.49	1.26	13	30	4	13.23	1.00	18	1.73	......	2.91
68	8.04	0.19	27	3.85	0.14	12.51	1.60	11	38	0	14.61k	4.02	12	1.68	8	5.90
69	6 93	0.48	41	4.67	....	12.50	1.61	21	50	0 4	14.83	3.24	19	1.81	......	5.24
70	6 64	......	26	4.01	0.09	11.02	1.46	23	49	7	13.30	j	8	1.12	3	......
71	7.51	......	43	3.32	....	11.26	1.37	8	95	1	13 68	2.50	28	1.59	......	4.37
72	7.16	1.41	82	2.10	....	11.50	1.24	16	23	2	13.71	2.58	1	0.17	......	2.76
73	7.40	0.53	96	1.67	3.04 e	13.60	1.50	25	10	3	15.49	1 72	62	0.80	99 e	4.13
74	7.43	......	65	2.16	2.74 e	13.00	1.29	47	62	6	15.45	j	21	1.12	j	......
75	6.35	1.28	48	3.76	....	11.89	1.55	8	23	2	13.80	2.30	j	1.71	......	......
76	5.74	1.00	38	3.23	....	10.37	1 40	15	46	2	12.42	3.71	19	1.59	......	5.49
77	7.49	1.44	42	3.88	0.41	13.66	1.44	24	37	4	15.77	2.53	22	1.50	1	4.26
78	4.26	1.55	45	0.97	3.61 e	10.86	1.57	35	79	3	13.62	2.16	9	0.54	126 e	4.05
79	6.19	0.61	86	2.76	1.51 e	11.95	1.42	22	95	3	14.59	1.42	33	1.41	j	......
80	6 80	......	73	4.70	....	12.24	1.62	17	44	4	14.52	0.90	4	u	......	0.94
81	6.34	1.37	121	2.42	....	11.35	1.80	46	40	4	14 07	0.78	85	u	.....	1.63
82	4.68	1.57	125	2.18	....	9.70	2.28	38	32	8	12.78	0.25	15	0.20	. ...	0.60
83	6.41	1.41	96	1.98	....	10.78	1.99	19	49	10	13 56	1.62	24	0.08	......	1.94
84	5.89	0.68	83	2.88	1.34 e	11.65	1.44	24	64	3	14.01	j	33	1.54	j	......
85	4.90	0.57	122	0.16	4.27 e	11.13	1.73	36	32	11	13.67	0.08	j	j	j	......
86	6.36	0.79	40	3.05	....	10.62	1.80	9	44	3	12.99	4.10	25	1.48	......	5.83
87	7.92	0.59	66	3.64	....	12.72	1 36	8	56	0.9	14.75	4.01	25	1.59	......	5.85
88	5.79	0.16	63	3.82	....	10.41	1.86	19	51	2	13.00	1.00	7	1.39	......	2.46
89	8.76	......	25	3.08	....	12.11	1.64	10	96	2	14.85	4.18	16	1.47	......	5.81
90	6.25	0.34	33	4.97	....	11.91	1.56	5	66	9	14.29	2.16	1	2.93	......	5.10
91	1.56	.007	40	5.19	....	7.17	1.81	5	55	3	9.63	0.09	12	0.07	......	0.28
92	2.16	......	47	4.56	....	7.20	2 60	19	17	8	10.26	0.58	j	u	......	......
93	3.31	......	52	5.49	....	9.33	1.58	53	27	2	11.74	0.80	19	2.70	......	3.69
94	3.34	......	36	4.60	....	8.30	1.96	17	83	3	11.31	0.70	15	0.86	......	1.71
95	2.66	0.10	64	4.70	....	8.11	1.64	45	148	8	11.77	j	j	j	......	......
96	2.58	0.09	39	4.47	....	7.55	1.83	17	28	3	9 88	0.54	7	0.46	......	1.07
97	3.02	......	31	5.06	....	8.40	1.87	14	41	3	10.86	h¹	15	i¹	......	......
98	4.21	......	75	5.78	....	10.74	1.80	15	9	1	12.81	1.49	20	1.10	......	2.79
99	2.68	......	29	4.23	....	7.21	1.91	6	23	2	9.44	0.45	11	j	. . ..	......
100	1.96	......	32	4.24	....	6.52	1.73	15	70	3	9.16	0.56	13	u	......	0.69
101	1.98	0.01	39	5.03	....	7.41	2.08	20	87	1	10.61	0.57	15	0.40	......	1.02
102	4.26	....	22	4.38	....	8.87	1.21	28	40	3	10.82	f¹	2	1.01	......	1.03
103	3 64	0.13	56	4.99	.. ..	9.32	1.35	13	30	2	11.14	1.04	18	j¹	......	......
104	3.95	......	71	3.25	....	7.92	1 40	22	21	5	9.82	1.29	14	0.46	......	1.89
105	3.94	......	23	3.87	0.28	8.34	1.32	8	14	3	9.93	0.67	j	j	j	......
106	3.73	0.13	52	4.26	....	8.65	1.25	11	11	2	10.16	1.17	15	j¹	......	......
107	4.15	......	49	4.93	....	9.57	1.37	10	98	3	12.07	1.77	5	1.17	......	2.99
108	4.97	......	....	3.87	....	8.85	0.78	4	29	4	10.02	0.73	k¹	0.38	......	......
109	4.93	......	81	4.02	....	9.76	1.47	15	99	1	12.40	l¹	31	1.19	......	......
110	3.41	......	48	4.26	....	8.16	0.59	17	59	10	9 62	0.52	15	0.77	......	1.44
111	4.21	......	96	5.39	......	10.57	1.48	17	61	7	12.91	0.23	30	1.20	......	1.73
112	4.69	......	70	3.01	....	8.41	1.38	15	50	2	10.48	0.81	30	0.73	......	1.84
113	5.08	......	75	3.98	....	9.81	1.00	25	49	1	11.59	0.33	10	u	.....	0.43
114	4.09	......	77	4.49	....	9.36	1.31	43	67	4	11.82	0.87	37	1.68	......	1.92
115	4.50	2.01	38	2.88	0.007	9.88	1.41	24	48	3	a¹	0.41	6	0.09	......	0.56
116	3.68	g	53	5.28	0.03	9.52	0.76	6	49	3	10.89	1.36g	26	0.72	j	2.34
117	5.44	b¹	85	2.76	c¹	9.06	0.71	d¹	133	d¹	e¹	j	j	j	j	......
118	1.77	......	....	5.55	....	7.32	0.75	22	35	10	8.76	f¹	....	m¹	......	......

the value of lead, zinc and other incidental products per ton of iron produced, leaving $11.02 as the total net cost. [b¹] The expenditures for cinder, scrap, etc., are inseparably combined with those for ore and limestone. [c¹] The expenditures for coal are inseparably combined with those for coke [d¹] The expenditures for officials and clerks and taxes are inseparably combined with those for supplies and repairs. [e¹] From the total of $11.10 subtract $0.61, the value of lead and zinc per ton of iron produced, leaving $10.48 as the total net cost. [f¹] Ore mines located at works. [g¹] Part of the coke is brought 142 miles at a cost of $1.35 per ton, and part 241 miles at a cost of $2.02 per ton. [h¹] Part of the ore is brought 6 miles at a cost of 10 cents per ton, and part 75 miles at a cost of 70 cents per ton. [i¹] Part of the coke is brought 125 miles at a cost of $1.15 per ton, and part 375 miles at a cost of $2.25. per ton. [j¹] Part of the coke is brought 13 miles at a cost of 30 cents per ton, and part 400 miles at cost of $1.80 per ton. [k¹] Limestone quarries located at works. Amount used not given [l¹] Part of the ore is brought 11 miles at a cost of 30 cents per ton, and part 69 miles at a cost of 55 cents per ton. [m¹] Part of the coke is brought 142 miles at a cost of $1.35 per ton, and part 241 miles at a cost of $2.03 per ton. [n¹] From $2.89 to $3.91. [o¹] $0.58 to $2.85. [p¹] From $4.34 to $5.06. [q¹] From $4.56 to $6.97

COST OF PRODUCING IRON BY THE THOMAS IRON COMPANY FROM 1855.

Tons of 2240 lbs.

Six Months Ending	Cost Per Ton. Coal.	Cost Per Ton. Ore.	Cost Per Ton. L'stone.	Amount Used per Ton Pig. Coal. T.	Coal. Lbs.	Ore. T.	Ore. Lbs.	L'stone T.	L'stone Lbs.	Cost per Ton Pig. Coal.	Ore.	L'stone.	Labor, Repairs, etc.	Total Cost.	Quality and Quantity. 1 Ex.	2 Ex.	No. 2.	No. 3	Total Product.	Running Time, Weeks.	Days.
	$	$	$							$	$	$	$	$							
Dec., 1855	3.10	3.59	.63	2	968	2	1,252	1	1,357	7.55	9.50	.98	2.54	20.57	....	....	....	....	6,445	39	5
June, 1856	2.95	3.75	.57	2	835	2	1,353	1	834	7.00	9.61	.78	3.08	20.47	....	....	....	....	10,608	52	5
Dec., "	2.89	3.65	.54	2	560	2	892	1	976	6.50	8.75	.78	5.94	21.97	....	....	....	....	6,838	40	0
June, 1857	2.84	3.69	.52	2	465	2	858	1	630	6.27	8.34	.67	4.08	19.37	....	....	....	....	10,534	51	5
Dec., "	2.80	3.30	.52	2	336	2	804	1	537	6.02	7.72	.65	4.23	18.61	....	....	....	....	7,564	39	5
June, 1858	2.54	2.88	.43	2	11	2	813	1	544	5.09	6.68	.54	3.49	15.80	....	....	....	....	7,732	32	4
Dec., "	2.43	2.81	.37	1	2,175	2	566	1	699	5.80	6.33	.48	2.55	15.16	....	....	....	....	12,256	52	2
June, 1859	2.42	2.62	.34	2	161	2	701	1	733	2.02	6.06	.46	2.85	14.39	....	....	....	....	11,767	49	2
Dec., "	2.39	2.61	.34	2	170	2	870	1	500	4.97	6.23	.41	4.29	15.91	....	....	....	....	10,429	52	0
June, 1860	2.44	2.60	.35	1	2,056	2	885	1	778	4.68	6.23	.47	4.13	15.50	....	....	....	....	11,155	46	0
Dec., "	2.45	2.86	.30	1	1,949	2	633	1	655	4.58	6.52	.46	2.46	14.02	....	....	....	....	13,699	52	1
June, 1861	2.37	2.70	.34	1	2,218	2	685	1	854	4.72	8.23	.47	2.58	14.00	....	....	....	....	13,219	51	5
Dec., "	2.36	2.62	.33	2	85	2	627	1	789	4.82	5.98	.44	2.34	13.58	....	....	....	....	13,777	52	2
June, 1862	2.37	2.39	.34	2	56	2	531	1	824	4.79	5.34	.47	2.45	13.05	....	....	....	....	12,784	52	0
Dec., "	2.70	2.63	.32	2	323	2	363	1	567	5.80	5.69	.41	2.11	14.01	....	....	....	....	17,902	77	5
June, 1863	3.80	2.60	.45	2	224	2	676	1	737	7.99	6.00	.60	4.45	19.03	....	....	....	....	16,968	72	1
Dec., "	4.92	3.03	.49	2	579	2	909	1	978	11.11	7.29	.71	4.94	24.05	....	....	....	....	18,724	78	5
June, 1864	5.66	3.59	.55	2	435	2	871	1	1,112	12.42	8.59	.82	4.65	26.48	....	....	....	....	23,317	102	0
Dec., "	7.03	4.79	.73	2	777	2	949	1	1,427	16.51	11.60	1.16	6.80	36.07	....	....	....	....	21,162	95	4
June, 1865	6.13	4.68	.80	2	907	2	1,166	1	1,416	14.75	11.78	1.30	6.64	34.48	....	....	....	....	14,320	68	0
Dec., "	5.69	4.72	.69	2	443	2	75	1	1,128	12.06	10.87	1.04	5.73	29.70	....	....	....	....	17,189	72	0
June, 1866	4.85	4.34	.76	2	262	2	758	1	1,078	10.27	10.11	1.13	5.67	27.18	....	....	....	....	23,496	101	1
Dec., "	4.44	4.94	.74	2	605	2	523	1	1,116	10.07	11.02	1.11	5.16	27.36	....	....	....	....	23,556	96	5
June, 1867	4.00	4.90	.72	2	903	2	687	1	1,065	9.61	11.30	1.07	5.98	27.97	....	....	....	....	22,153	96	4
Dec., "	3.54	4.56	.75	2	890	2	642	1	1,207	8.57	10.43	1.16	4.99	25.14	....	....	....	....	24,987	104	0
June, 1868	3.41	4.60	.76	2	466	2	875	1	1,140	7.53	11.00	1.14	6.54	26.21	....	....	....	....	26,214	100	6
Dec., "	4.14	4.53	.78	2	436	2	787	1	1,011	9.00	10.64	1.17	6.52	27.33	....	....	....	....	27,448	124	5
June, 1869	4.16	4.66	.79	2	132	2	554	1	1,366	8.57	10.47	1.27	5.24	25.56	....	....	....	....	28,808	130	0
Dec., "	4.95	4.98	.82	2	80	2	375	1	1,345	10.07	10.79	1.30	6.11	28.27	....	....	....	....	33,352	155	0
June, 1870	3.98	4.89	.81	1	2,001	2	489	1	1,059	7.53	10.85	1.20	5.05	24.62	....	....	....	....	33,357	156	0
Dec., "	3.78	4.72	.81	2	32	2	579	1	1,067	7.61	10.66	1.20	4.93	24.41	....	....	....	....	33,507	156	0
June, 1871	4.23	4.86	.79	2	61	2	814	1	1,161	8.59	11.48	1.20	8.06	29.33	....	....	....	....	16,313	86	3
Dec., "	3.77	4.98	.73	1	2,032	2	493	1	916	7.18	11.06	1.03	3.84	23.12	....	....	....	....	36,301	156	0
June, 1872	3.69	5.24	.74	1	1,921	2	252	1	944	6.84	11.59	1.05	4.60	24.08	....	....	....	....	36,311	156	0
Dec., "	3.75	6.22	.75	2	116	2	749	1	1,361	7.69	14.51	1.20	5.79	29.20	....	....	....	....	32,167	156	0
June, 1873	3.85	5.95	.75	1	2,039	2	471	1	1,410	7.36	13.15	1.20	7.40	29.11	....	....	....	....	32,676	156	0
Dec., "	3.85	6.02	.73	2	60	2	796	1	1,412	7.82	14.21	1.20	6.50	29.72	....	....	....	....	26,420	131	0
June, 1874	3.86	5.88	.66	1	2,138	2	799	1	1,140	7.39	13.64	1.00	5.44	27.49	....	....	....	....	19,521	109	3
Dec., "	3.86	5.75	.61	1	1,856	2	183	1	771	7.06	11.98	.83	5.27	25.14	....	....	....	....	21,592	100	0
June, 1875	4.28	5.30	.57	1	1,904	2	178	1	737	8.12	11.03	.76	3.82	23.74	....	....	....	....	21,326	104	0
Dec., "	3.41	5.19	.55	1	1,678	1	2,124	1	352	5.99	10.12	.64	3.56	20.32	....	....	....	....	21,972	92	2
June, 1876	3.36	4.89	.52	1	1,412	1	2,137	1	231	5.39	9.54	.58	2.49	18.06	6,939	12,164	4.927	230	24,260	100	5
Dec., "	2.85	4.40	.50	1	1,769	2	343	1	602	5.11	8.98	.64	2.60	17.33	4,380	12,226	11,202	745	28,553	130	2
June, 1877	2.63	4.00	.49	1	1,526	2	131	1	500	4.42	8.20	.59	2.29	15.50	6,428	10,851	13,854	3,032	34,165	138	0
Dec., "	2.58	3.73	.49	1	1,705	2	211	1	549	4.58	7.83	.61	3.19	16.21	6,228	9,231	12,134	2,361	29,954	111	3
June, 1878	2.68	3.50	.50	1	1,476	2	183	1	743	4.43	7.29	.66	2.09	14.47	8,547	13,560	13,806	1,370	37,283	155	3
Dec., "	2.78	3.25	.46	1	1,257	2	241	1	610	4.31	6.83	.58	2.64	14.36	5,409	13,095	6,946	613	26,063	109	1
June, 1879	2.58	3.11	.44	1	1,420	2	81	1	499	4.25	6.34	.54	2.46	13.59	4,815	10,394	15,544	1,235	31,988	136	3
Dec., "	2.63	3.52	.45	1	1,409	1	2,180	1	314	4.29	6.60	.51	2.47	13.87	6,895	11,253	28,388	2,771	49,307	197	0
June, 1880	3.41	4.19	.49	1	1,593	2	135	1	376	5.77	7.94	.56	2.24	16.51	9,399	12,261	25,647	3,298	50,605	208	0
Dec., "	3.58	3.79	.49	1	1,818	2	316	1	944	6.48	8.25	.70	2.04	17.47	9,337	14,991	22,762	1,809	48,899	208	0
June, 1881	3.57	4.88	.51	1	1,671	2	391	1	843	6.23	8.28	.70	2.21	17.42	14,098	18,510	19,352	1,800	53,760	208	0
Dec., "	3.54	3.79	.55	1	1,553	2	109	1	803	6.00	7.99	.73	3.01	17.73	8,334	15,235	19,700	2,481	45,754	181	3
June, 1882	3.52	4.10	.53	1	1,337	2	143	1	605	5.63	8.34	.68	2.83	17.48	10,760	16,759	23,812	3,578	54,909	214	4
Dec., "	3.52	5.54	.52	1	1,421	2	140	1	607	5.74	7.89	.66	3.18	17.48	12,483	19,407	20,051	3,763	55,705	207	4
June, 1883	3.78	3.70	.51	1	1,352	2	192	1	468	5.72	7.74	.62	2.93	17.01	13,675	21,339	20,491	2,217	57,722	219	..
Dec., "	3.38	3.32	.47	1	1,263	2	102	1	210	5.29	7.29	.51	2.76	15.85	14,445	16,163	11,953	1,296	43,857	159	5
June, 1884	3.28	3.20	.44	1	1,227	2	132	1	113	5.06	6.92	.46	2.46	14.90	14,328	13,875	14,856	1,774	44,834	155	6
Dec., "	2.82	2.97	.44	1	1,208	2	181	1	171	4.43	6.97	.48	2.67	14.55	12,256	13,840	16,557	1,119	43,772	150	6
June, 1885	2.84	3.13	.45	1	1,076	2	227	1	250	4.24	6.61	.50	2.28	13.63	13,772	14,333	21,162	1,150	50,418	160	4
Dec., "	2.86	2.89	.47	1	902	2	21	1	085	4.00	5.98	.49	2.59	13.06	8,352	10,772	32,418	2,252	53,794	170	0
June, 1886	2.82	3.18	.47	1	976	2	190	1	422	4.05	6.71	.56	2.38	12.70	16,958	18,510	41,551	2,284	79,304	264	4
Dec., "	2.87	3.24	.49	1	945	2	127	1	233	4.08	6.82	.54	2.50	13.94	13,826	23,071	45,334	2,208	84,439	274	2
June, 1887	3.13	3.63	.52	1	1,039	2	361	1	356	4.57	7.50	.60	2.35	15.02	13,892	20,143	50,520	3,621	88,176	303	2
Dec., "	3.27	3.41	.52	1	1,173	2	172	1	211	4.97	7.05	.57	2.82	15.41	12,517	23,749	37,846	2,900	77,013	283	4
June, 1888	3.27	3.48	.53	1	1,125	2	5	1	191	4.91	6.76	.57	2.30	14.54	14,220	19,171	42,447	3,761	79,599	259	4
Dec., "	2.77	3.72	.51	1	901	1	2,036		1,876	3.91	6.85	.43	2.52	13.71	14,602	17,967	48,518	3,101	84,187	252	0
June, 1889	2.72	3.77	.50	1	908	1	1,956		1,746	3.82	6.98	.39	2.72	13.91	11,740	14,140	43,501	2,096	71,477	216	6
Dec., "	2.75	4.48	.51	1	819	1	1,882		1,895	3.69	7.37	.42	2.25	13.74	26,481	21,625	37,894	1,917	87,918	259	5
June, 1890	2.80	3.97	.50	1	792	1	1,843		1,474	3.78	7.21	.35	2.42	13.76	16,826	18,438	48,413	3.493	87,170	267	6
Dec., "	2.61	3.63	.58	1	813	1	1,852		1,490	3.75	7.32	.36	2.77	14.20	17,123	20,240	48,195	1,538	87,096	236	4
June, 1891	2.63	3.77	.50	1	865	1	1,908		1,587	3.69	6.69	.35	2.81	13.54	15,237	18,322	42,791	2.106	78,456	236	1
Dec., "	2.75	4.21	.49	1	866	1	1,995		1,829	3.62	6.98	.40	3.10	14.10	17,158	16,973	41,839	1,575	77.546	243	3
June, 1892	2.64	3.52	.52	1	712	1	1,894		1,546	3.48	6.68	.35	2.43	12.94	19,796	16,608	41,434	2,554	80.392	220	3
Average per six months.	3.01	3.7555	.495	1	1,222	2	42	1	196	4.66	7.3555	.536	2.57	15.121	12,159	16,021	28,056	2,183	58,420		

STEEL.

Rapid as the progress in this country of the production of pig-iron has been during the past 27 years, the manufacture of steel has proceeded with even greater velocity. Since 1865 the output of pig-iron has doubled itself 3½ times, while the manufacture of steel has doubled itself more than 8 times, rising from 13,627 tons to about 4,000,000 tons in 1892. If the production of pig-iron in this country had proceeded at the same rate as the manufacture of steel, we should now be making close on to 250,000,000 tons per annum, an amount nearly 10 times as much as the pig-iron production of the world. No better illustration of the great changes that have come upon the iron and steel industry during the last quarter of a century can be found than this statement, and yet it expresses but a part of the truth.

Neglecting for the moment our imports and exports of iron and steel, in 1865 we turned into steel 1.63% of our pig-iron, while in 1892 the production of steel was close to 44% of the output of pig-iron. We now require 300 times as much steel as we did then, but only about 11 times as much pig-iron, and the disproportion seems to be increasing.

The manufacture of steel as a commercial commodity in this country seems to have begun in Connecticut about the year 1744, by which time, however, not more than half a ton had been made. In 1750 there was a steel furnace in Massachusetts and in New Jersey, and three in Pennsylvania. Just prior to, during, and after the Revolution steel was made in some quantity; in 1791 about half the consumption was of domestic make. In 1810 the production was about 900 tons, Pennsylvania's output being 531 tons. In 1831 there were 14 blister-steel furnaces in the United States, with a combined capacity of 1600 tons per annum, which figures would represent also the importation of all kinds of steel.

Crucible or cast steel seems to have been made successfully in 1832 by Garrard Brothers at Cincinnati, Ohio, who used blister steel and produced an excellent quality of tool steel. But the manufacture of cast steel did not thrive, for even as late as 1850 the quantity made in the entire State of Pennsylvania was less than 50 tons, while for blister steel the yearly capacity of her 13 establishments was 6000 tons. So far as can be ascertained, it was not until 1867 that our production of all kinds of steel exceeded 19,000 tons per annum. At the present time 9 States are producing crucible steel, viz., Pennsylvania, New Jersey, New York, Massachusetts, Connecticut, Tennessee, Ohio, Indiana, and Michigan, the first-named making three fourths of the total output. The production remains about the same from year to year. There are 46 crucible-steel works in the United States, with about 3000 pots.

In the following table will be seen the production of iron and steel in the United States since 1864, imports and exports since 1867, and value of imports and exports for certain years. The most important facts it reveals are the gradual replacement of iron by steel rails, and the growth of the Bessemer and open-hearth processes. Since 1867, when Bessemer-steel rails of American manufacture first began to compete with iron rails, the production of steel rails has grown from 2277 tons to 1,268,500 tons, while that of iron rails has fallen from 410,319 tons to 10,000 tons. Since 1867 our imports of rails have fallen from 145,579 tons to 366 tons and the consumption has risen from 558,017 to 1,278,916 tons.

PRODUCTION OF IRON AND STEEL AND THEIR PRODUCTS IN THE UNITED STATES, 1864 TO 1892.

	Iron.					Steel.							No. of Kegs Cut Nails and Spikes.
						Rails.		Ingots.					
	Pig.	Spiegel and Ferro-manganese.	Blooms.	Rolled.	Rails.	Bessemer.	Open-hearth.	Bessemer.	Open-hearth.	Crucible.	Miscellaneous.	Total.	
1864..	......	c	c	479,426	299,436	None	None	None	None	c	c	c	....
1865..	831,770	c	57,122	446,471	318,118	"	"	"	"	c	b13,627	13,627	....
1866..	1,205,663	c	65,674	531,528	384,623	"	"	"	"	c	b16,940	16,940	....
1867..	1,305,122	c	65,243	517,712	410,319	2,277	"	2,679	"	c	b16,964	19,643	....
1868..	1,430,900	c	67,143	534,184	445,973	6,451	"	7,589	"	c	b19,197	26,786	....
1869..	1,711,286	c	62,054	573,589	521,371	8,616	"	10,714	893	c	b19,643	31,250	....
1870..	1,665,178	c	55,888	629,464	523,214	30,357	"	37,500	1,340	c	b28,124	66,964	....
1871..	1,706,892	c	56,250	633,928	658,467	34,152	"	40,179	1,786	c	b31,249	73,214	....
1872..	2,548,729	c	51,786	841,064	808,866	83,991	"	107,239	2,679	26,125	6,911	142,954	4,065,322
1873..	2,560,959	c	55,860	961,043	679,519	115,192	"	152,368	3,125	31,059	12,245	198,827	4,024,704
1874..	2,401,263	c	55,062	991,203	521,848	129,414	"	171,368	6,250	32,436	5,672	215,726	4,912,180
1875..	2,023,735	6,993	43,967	980,238	447,901	259,699	"	335,283	8,080	35,179	11,256	389,798	4.726,881
1876..	1,868,959	5,907	39,847	930,447	417,114	368,268	"	469,639	19,188	35,162	9,202	533,191	4,157,814
1877..	2,066,593	7,897	42,232	1,021,624	296,910	385,865	"	500,524	22.349	36,098	10,646	569,617	4,828,918
1878..	2,301,214	9,530	44,683	1,100,612	288,295	491,427	8,390	653,773	32,225	38,308	7,639	731,975	4,396,130
1879..	2,741,851	12,438	55,672	1,452,968	375,143	610,682	8,169	829,440	50,259	50,696	4,878	935,273	5,011,021
1880..	3,835,190	17,503	66,597	1,641,880	440,859	852,196	12,156	1,074,261	100,851	64,664	7.558	1,247,334	5,370,512
1881..	4,144,252	18,827	75,541	1,924,416	436,233	1,187,769	22,515	1,374,247	131,202	80,145	2,720	1,588,314	5,794,206
1882..	4,623,232	19,610	81,511	2,023,176	203,459	1,284,067	20,325	1,514,688	143.341	75,972	2,691	1,736,692	6,147,097
1883..	4,595,510	21,941	66,748	2,039,214	57,994	1,148,709	8.202	1,477,345	119,356	71.835	4,998	1,673,534	7,762,737
1884..	4,097,869	30,261	66,968	1,724,774	22,821	996.983	2.384	1,375.531	117,515	53.269	4.563	1,550,879	7.581,379
1885..	4,044,524	30,849	37,232	1,597.960	13,228	959,470	4,279	1,519,430	133.376	57.599	1,514	1,711,919	6,696,815
1886..	5,683,326	42,841	37,418	2,017,806	21,142	1,574.703	4.692	2,269,190	218.973	71,972	2,367	2,562,502	8,160,973
1887..	6,417,156	42,498	38,666	2,290,569	20,591	2,101,904	17.145	2,936,033	322,069	75,376	5,594	3.339,072	6,908,870
1888..	6,489.738	48,901	35,603	a3,213.648	12,725	1,386,278	4,698	2,511,160	314,318	70,279	3,682	2,899,439	6,493,591
1889..	7,603,640	76,628	32,375	a3,714.723	9,159	1,510,057	2,988	2,930,204	374,543	75,865	5,119	3,385.731	5,810,758
1890..	9,202,702	133,180	27,485	a4,137,567	13,882	1,867,837	3,588	3.688,870	513.232	71.175	3,793	4,277,070	5,640,946
1891..	8,279,870	127.766	26,088	a4,083,787	8,240	1.293,053	5,883	3,247,417	579,753	72,587	4,484	3,904,241	5,002,176
1892 .	9,157,000	179,131	25,000	a4.613.970	10,437	1.458.732	3,819	4,168,435	669,889	84.709	4,548	4,927,581	4,507,819

NOTES.—(a) Includes rolled steel. (b) Includes crucible and all other steels. (c) No records obtainable.

UNITED STATES IMPORTS OF IRON AND STEEL, TIN-PLATE, ETC., 1867 TO 1892.

Year.	Pig, Scrap (Iron and Steel), Spiegel, and Ferromanganese.		Bar-iron.		Castings, Boiler-iron, Band, Hoop, Cotton Ties, Scroll, Sheet, and Tagger's Iron.		Steel Ingots, Billets, Blooms, Slabs, Sheets, etc.		Tin and Terne Plates.		Rails.	
	Am't.	Value.	Am't.	Value.	Am't.	Value.	Amount	Value.	Am't.	Value.	Am't.	Value.
	tons	$	tons	$	tons	$	tons	$	tons	$	tons	$
1867a.	147,481	2,605,224	67,280	3,182,864	d28,341	1,888,967	18,729	2,778,534	......	e6,276,136	103,362	3,299,024
1868a.	192,381	3,405,067	56,382	2,636,198	d20,919	1,435,246	13,427	1,961.823	......	e6,893,072	140,060	4,056,830
1869a.	272,755	4,632,111	77,281	3,215,776	d21,041	1,489,598	17,588	2,596,013	e76,716	e8,565,432	224,085	6,777,406
1870a.	328,032	5,581,471	68,104	3,028,213	d24.346	1,548,979	14,024	2 013,577	e66,657	e7,628,871	288,802	9,678,305
1871..	415,960	8,642,390	109,433	5,024,686	23,182	1,507,672	a18,644	2,829,066	82,968	9,946,373	505,538	19,132,359
1872.	512,700	14,887,313	79,978	4,837,532	15,540	2,110,178	a20,687	3,185,457	85,628	13,893,450	473,974	22,705,025
1873..	235,310	8,243,606	55,583	4,481,614	17,574	1,691,119	a18,994	2,230,843	97,177	14,240,868	231.046	13,692,292
1874..	90,882	2,688,190	23,996	1,936,793	7,393	1,123,251	a12,198	2,447,345	79,787	13,057,658	96,705	7.234,578
1875..	100,785	2,305,113	24.591	1,729,743	3,913	655,199	a12,396	2,157.766	91,054	12,098,885	17,364	1,108,251
1876..	86,804	2,031,961	23,798	1,532,361	1,742	224,870	a8,584	1,433,979	89,946	9,416,816	256	6,603
1877..	69,432	1,487,366	27,260	1.477.224	1,248	130.805	a6,029	1,001,328	112,478	10,679.028	31	1,559
1878..	72,062	1,585,609	29,720	1,515,598	817	100,285	a5,155	879,098	107,864	9,069,967	9	435
1879..	543,840	8,919,424	43,607	1,780,736	5.930	571,144	a4,777	785,979	154,250	13,227,659	39,417	1,008,747
1880..	1,320,750	29,703,091	113,380	5,721,828	33,047	1,990,318	a9.090	1,421,521	158,049	16,518,113	259,543	9,192,901
1881..	599,948	11,628,537	42,696	2,075,161	9,070	699,179	a68,796b	3,578,166	183,005	14,886,907	344,930	11.114,487
1882..	687,115	12,633,152	70,732	3,304,967	19,138	1,143.795	a218,338	7,642,302	213.987	17,975,161	200,112	6,481,039
1883	386,934	6,760,862	42.329	1,914,474	9.033	723,751	a76.957	2,373,883	221.233	18,156,773	34 799	1,068.840
1884..	194,608	3,685,048	36,605	1,588,464	24,296	1,310,037	21,973	1.310,362	216,183	16,858,650	2,829	69,779
1885..	162,523	2,728,923	31,474	1,401,213	26,360	1.254.317	30,105	1,249,123	228,597	15,991,152	2,188	56,694
1886..	451,043	6,656,820	29,148	1,250,456	20.767	1,034,603	149,336	3,298.707	257,686	17,495,564	41,588	887,433
1887..	807,460	12,212,650	36,218	1,400,0:5	51,864	1,982,361	310,552	6.543.935	283,831	18,699,145	137,829	2,988,531
1888..	251,215	3,651,850	31,744	1,119,107	c60,140	c2,140,150	103,577	2,822,870	297.871	19,752,180	60,960	1,525,158
1889..	180,388	3,344,593	29,570	1,097,132	c41,867	c1,858,852	72,808	1,989,837	323,274	21,726.707	6,217	163,339
1890..	191,232	4,535,526	24,034	1,002,480	c30,218	c1,515,225	28,636	1,578,286	329,435	23,670,158	204	5,035
1891..	67,179	1,432,455	18,099	770,858	c12,753	c781,557	34,685	1,673,214	327,868	25,900,305	253	8,405
1892*.	103,089	2,054,956	18.460	706.570	23.995	1,340,556	31,566	1,589,637	278,498	17,797,549	366	12,000

(a) Fiscal year ending June 30. (b) Blooms just reported. (c) Includes sheet steel. (d) Quantities of tagger's iron not separately obtainable, but values are included. (e) Includes tagger's iron.
* The returns for the last month of 1892 are estimated.

EXPORTS OF IRON, STEEL, ETC., FROM THE UNITED STATES, 1867 TO 1892.

	Pig-iron.		Bar-iron.		Boiler, Band, Hoop, Scroll, and Sheet Iron.		Steel Ingots, Bars, Sheets, and Wire.		Rails.		Total Value.*
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Tons	$	Tons	$	Tons	$	Tons	$	Tons	$	$
1867....	624	27,021	177	16,573	26	2,699	13	2,408	158	23,823	7,413,984
1868....	281	10,726	166	20,269	a61	18,690	7	8,631	9	1,424	9,037,936
1869....	61	4,112	138	13,088	....	....	....	....	229	18,665	8,822,367
1870....	1,390	50,127	228	26,024	69	7,793	21	5,755	801	65,081	11,002,902
1871....	3,498	111,033	182	16,754	64	7,906	7	2,538	220	17,445	19,005,090
1872....	2,026	69,331	37	4,532	173	21,077	29	8,146	87	7,167	8,747,106
1873...	2,816	140,683	308	33,767	97	10,657	8	3,955	1,265	104,054	11,119,831
1874....	9,641	414,728	1,965	173,168	163	24,522	301	26,691	341	25,356	13,180,654
1875...	15,797	489,362	5,323	392,420	200	22,732	58	16,830	1,749	101,557	17,385,738
1876....	6,792	181,663	8,398	607,921	103	10,374	60	13,208	1,002	57,109	13,454,514
1877....	3,180	89,029	2,874	194,775	201	35,723	67	15,661	5,289	243,811	14,468,039
1878....	5,781	140,148	2,519	133,373	232	24,549	70	15,892	8,328	324,986	13,969,275
1879....	3,048	85,949	991	58,987	657	48,056	49	9,084	b6,293	233,514	13,074,235
1880....	1,871	70,496	342	31,426	250	27,417	132	35,568	958	47,212	15,156,703
1881....	6,157	184,364	445	32,325	164	14,473	195	46,495	610	41,427	18,216,121
1882...	5,576	186,221	756	60,628	146	14,962	447	89,076	2,996	208,228	22,348,834
1883...	3,768	111,414	107	72,054	e157	15,721	d367	76,447	2,308	134,670	22,716,040
1884....	3,840	92,336	832	52,872	460	45,907	c2,355	296,072	6,034	223,535	19,290,895
1885....	6,228	123,605	833	48,048	456	34,254	3,059	312,080	7,757	278,392	16,622,411
1886....	8,849	161,072	809	44,999	1,151	77,045	4,186	380,408	2,644	87,308	14,865,087
1887....	6,796	129,918	860	54,485	425	36,359	4,648	408,516	549	22,746	16,235,922
1888....	14,356	256,563	587	40,749	2,183	199,478	6,727	558,108	8,908	232,002	19,578,489
1889....	13,573	227,048	778	52,341	339	29,540	8,738	689,784	9,325	309,825	23,712,814
1890....	16,341	266,107	1,068	97,317	609	48,168	10,721	886,244	16,948	577,916	27,000,134
1891....	14,945	258,000	1,341	85,382	506	34,019	12,516	940,375	11,239	363,488	30,736,442
1892†...	14,252	263,868	789	52,742	522	30,386	13,435	937,370	6,536	215,481	33,000,000

NOTE.—From 1867 to 1879 the returns are for fiscal years ending June 30; from 1880 to 1892 the returns are for calendar years.

(a) Weight of boiler-plate first reported.
(b) Steel rails first reported.
(c) In 1884 the exports of wire suddenly increased.
(d) Not including wire.
(e) Not including boiler-plate.
* Includes all manufactures of iron and steel as classified by Census Bureau.
† The returns for the last month of 1892 are estimated.

TOTAL VALUE OF UNITED STATES IMPORTS OF IRON AND STEEL (AND THEIR PRODUCTS), 1867–92.

1868*.....	$22,521,391	1873......	$60,005,538	1878......	$18,013,010	1883....	$48,714,297	1888....	$42,308,256
1869......	28,077,470	1874......	37,652,192	1879......	33,331,569	1884...	38,211,800	1889....	42,027,742
1870......	32.489,198	1875......	27,363,101	1880......	80,483,365	1885....	31,144,552	1890....	44,540,413
1871......	57,866,299	1876......	20,016,603	1881......	61,655,077	1886 ...	41,630,779	1891....	41,983,626
1872......	75,617,677	1877	19,874,399	1882......	67,075,125	1887...	56,420,607	1892....	33,879,877

* 1867 = $28,996,274.

TOTAL VALUE OF IRON AND STEEL, AND MANUFACTURES OF, EXPORTED FROM THE UNITED STATES, BY YEARS, 1827 TO 1866.

	$		$		$		$		$		$		$		$
1827.	273,158	1832.	212,830	1837	492,198	1842	1,109,522	1847	1,167,484	1852	2,303,819	1857	4,884,967	1862	4,526,971
1828.	231,234	1833.	233,812	1838	709,408	1843	a532,693	1848	1 259,632	1853	2,499,652	1858	4,729,874	1863	6,465.573
1829.	223,705	1834.	236,471	1839	944,550	1844	716,332	1849	1,096,172	1854	4.210,350	1859	5,503,667	1864	6,198,854
1830.	309,473	1835.	295,875	1840	1,104,455	1845	845,017	1850	1,911,320	1855	3,752,472	1860	5,703,042	1865	8,748,050
1831.	233,641	1836.	306,005	1841	1,045,264	1846	1,151,782	1851	2,255,698	1856	4,161,008	1861	5,924,647	1866	3,721,18[illegible]

NOTE.—Fiscal years ended Sept. 30 till 1842; on June 30 since.
(a) Nine months.

The extension of Bessemer and open-hearth steel to other purposes than the manufacture of rails has been a noticeable feature of the steel industry within the last 25 years. Thus in 1870 we turned into rails 81.30% of the output of Bessemer ingots, while in 1892 only about 40% was used in this way. The manufacture of rails from open-hearth steel seems to have been successfully begun in 1878, in which year 26.04% of the output was made into rails. But the active demand for it in other directions has so diminished its use in this way that the proportion now going into rails is only one per cent of the total output.

Bessemer Steel.—The first production of Bessemer steel in the United States was in September, 1864, at the Wyandotte Works, Michigan, under the direction of William F. Durfee, who used the Kelly process. The first steel rails made in this country were rolled by the North Chicago Rolling Mill, in May, 1865, from metal furnished by the Wyandotte Works. Some of them were in use in 1875. Iron rails (T-section) were first rolled at Mount Savage, Md., in 1844.

The following tables give the production, imports, and exports of iron and steel rails since 1849.

IRON AND STEEL RAILS: PRODUCTION, IMPORTS, AND CONSUMPTION IN THE UNITED STATES, 1849 TO 1863.

Year.	Rails in Tons of 2240 Lbs.			Railroads, Miles.	
	Home Production.	Imports, Fiscal Years.	Consumption.	Annual Increase.	Total Mileage.
1849	21,712	....	21,712	1,369	7,365
1850	39,359	....	39,359	1,656	9,021
1851	44,699	....	44,699	1,961	10,982
1852	55,784	....	55,784	1,926	12,908
1853	78,450	....	78,450	2,452	15,360
1854	96,443	....	96,443	1,360	16,720
1855	123,807	127,516	251,323	1,654	18,374
1856	160,730	155,495	316,225	3,642	22,016
1857	144,569	179,305	323,874	2,487	24,503
1858	146,162	75,745	221,907	2,465	26,968
1859	174,512	69,965	244,477	1,821	28,789
1860	183,069	122,175	305,244	1,837	30,626
1861	169,480	74,490	243,970	660	31,286
1862	190,990	8,611	199,601	834	32,120
1863	246,221	17,088	263,309	1,050	33,170

IRON AND STEEL RAILS: PRODUCTION, IMPORTS AND EXPORTS, AND CONSUMPTION IN THE UNITED STATES, 1864 TO 1892.

Record of Exports began in 1864.

	Rails, in Tons of 2240 Lbs.										Railroads, Miles.	
	Home Production.			Imports.			Exports.			Consumption.	Annual Increase.	Total Mileage.
	Iron.	Steel.	Total.	Iron.	Steel.	Total.	Iron.	Steel.	Total.			
1864	299,436	......	299,436	118,714		118,714	565		565	417,585	738	33,908
1865	318,118	......	318,118	77,518		77,518	1,155		1,155	394,481	1,177	35,085
1866	384,623	......	384,623	78,007		78,007	458		458	462,172	1,716	36,801
1867	410,319	2,277	412,596	145,579		145,579	158		158	558,017	2,249	39,250
1868	445,973	6,451	452,424	223,287		223,287	9		9	675,702	2,979	42,229
1869	521,371	8,616	529,987	279,609		279,609	229		229	809,367	4,615	46,844
1870	523,214	30,357	553,571	356,387		356,387	801		801	909,157	6,078	52,922
1871	658,467	34,152	692,619	505,538		505,538	220		220	1,197,937	7,371	60,293
1872	808,866	83,991	892,857	340,236	133,738	473,974	87		87	1,366,744	5,878	66,171
1873	679,519	115,192	794,711	88,572	142,474	231,046	1,265		1,265	1,024,492	4,097	70,268
1874	521,848	129,414	651,262	6,960	89,745	96,705	341		341	747,967	2,117	72,385
1875	447,901	259,699	707,600	1,048	16,316	17,364	1,749		1,749	723,215	1,711	74,096
1876	417,114	368,268	785,382	256	None	256	1,002		1,002	784,636	2,712	76,808
1877	296,910	385,865	682,775	None	31	31	5,289		5,289	677,517	2,280	79,088
1878	288,295	499,817	788,112	"	9	9	8,328		8,328	779,793	2,679	81,767
1879	375,143	618,851	993,994	17,045	22,372	39,417	5,142	1,151	6,293	1,027,118	4,817	86,584
1880	440,859	864,352	1,305,211	118,267	141,277	259,543	898	60	958	1,563,796	6,712	93,296
1881	436,233	1,210,284	1,646,517	122,333	222,597	344,930	533	77	610	1,990,837	9,847	103,143
1882	203,459	1,304,392	1,507,851	37,493	162,619	200,112	2,025	971	2,996	1,704,967	11,569	114,712
1883	57,994	1,156,911	1,214,905	676	34,123	34,799	517	1,791	2,308	1,247,396	6,743	121,455
1884	22,821	999,367	1,022,188	84	2,745	2,829	1,120	4,914	6,034	1,018,983	3,924	125,379
1885	13,228	1,063,749	1,076,977	50	2,138	2,188	273	7,484	7,757	1,071,408	2,982	128,361
1886	21,142	1,579,395	1,600,537	7	41,581	41,588	527	2,117	2,644	1,639,481	8,018	136,379
1887	20,591	2,119,049	2,139,640	241	137,588	137,829	26	523	549	2,276,920	12,878	149,257
1888	12,725	1,390,976	1,403,701	21	60,939	60,960	8	6,900	8,908	1,457,753	6,912	156,169
1889	9,195	1,513,045	1,522,240	6,217		6,217	1,082	8,243	9,325	1,519,132	5,184	161,353
1890	13,882	1,871,425	1,885,307	204		204	104	16,844	16,948	1,868,563	5,353	166,706
1891	8,240	1,298,936	1,307,176	253		253	160	11,079	11,239	1,296,190	4,089	170,795
1892	10,437	1,458,732	1,469,169	347		347	486	7,496	7,982	1,461,534	4,428	175,233

Imports for 1864 to 1866 are for fiscal years; the rest for calendar.

The honor of the invention of the pneumatic or Bessemer process for steel-making belongs to William Kelly, a Pennsylvanian, who in 1847, at the Eddyville Iron Works, Lyon County, Ky., was the first to refine molten pig-iron

by a blast of air in an acid-lined vessel. When the first Bessemer patents were taken out in this country, in 1856, Kelly's claim for priority was allowed by the Commissioner of Patents, and he was afterward given a certain sum of money and an annuity for the use of his process.

The Bessemer process should be styled the Kelly-Mushet-Bessemer, for Sir Henry Bessemer is by no means entitled to all of the credit for this, the greatest of all metallurgical achievements.

The Bessemer process it is, however, and likely to remain, for the wonderful success it has attained is due in greatest measure to the genius and perseverance of one man.

The frail foothold the process had secured in the United States, even so late as 1870, is all the more remarkable in view of the enormous profits of the English manufacturers. These profits were far beyond any that have ever been reached by any other industrial enterprise, and the statement of Sir Henry Bessemer himself, in a letter dated Sept. 10, 1890, is well worth reproduction:

"On the expiration of the 14-years' term of partnership of this firm, the works, which had been greatly increased from time to time, entirely out of revenues, were sold by private contract for exactly 24 times the amount of the whole subscribed capital, notwithstanding that the firm had divided in profits during the partnership a sum equal to 57 times the gross capital; so that by the mere commercial working of the process, apart from the patent, each of the five partners retired, after 14 years, from the Sheffield works with 81 times the amount of his subscribed capital, or an average of nearly cent per cent every two months—a result probably unprecedented in the annals of commerce."

But once it had fairly begun its course in the United States, Bessemer steel proceeded with unexampled rapidity, and we are now producing more than any other country. There are now 48 works and 98 converters, whereas in 1882 there were 15 works and 38 converters. The leading States concerned in its manufacture are Pennsylvania, Illinois, and Ohio, the first alone producing over 60% of the entire output at present. The production of Bessemer-steel ingots has doubled itself 10 times since 1867, and is now twice as great as it was in 1885. The industry is carried on in 10 States—Colorado, Illinois, Kentucky, Maryland, Massachusetts, New York, Ohio, Pennsylvania, West Virginia, and Wisconsin. For the last few years Pennsylvania and Illinois have produced over 75% of the total output of Bessemer steel, and the largest establishment in the country for the production of Bessemer pig-iron is in Illinois,—the Illinois Steel Company,—with a yearly capacity of 1,240,000 tons.

The tendency to build Bessemer-steel works nearer the great Bessemer-ore deposits of the Lake region will probably be more and more accentuated, especially since the drift of population and of railway construction is decidedly toward the Northwest. Improvements in the consumption of fuel whereby a ton of pig-iron is obtained with less than a ton of coke will also aid in the same movement, as the saving in freight will be from a quarter to half a ton per ton of pig.

Open-hearth or Siemens-Martin Steel.—The first open-hearth furnace for steel-making in this country was built by F. J. Slade at Trenton, N. J., for Cooper, Hewitt & Co., in 1868. All of the open-hearth steel made from that date to the close of 1883 was of the acid variety, the manufacture of basic open-hearth steel not having begun until 1884. The output of acid open-hearth steel from 1869, when the first statistics are available, to and including 1883, was 642,924 tons. It doubled itself 9½ times in 15 years. There are now in the United States 150 acid open-hearth furnaces.

All the crucible, Bessemer, and open-hearth steel down to 1884 was acid steel, i.e., made in vessels lined with highly siliceous material, and therefore requiring pig-iron low in phosphorus. Pig-iron destined for these processes must be made of very pure ores, such as contain little or no phosphorus or sulphur. These by no means comprise the great bulk of our ores, and were it not for other processes steel-makers would be restricted to the use of the crucible, the Bessemer, or the acid open-hearth (Siemens-Martin) process.

The Basic Process.—It has been estimated that fully 90% of the iron ores of the world are unsuited for the production of steel by either of these methods, and this estimate applies also to the United States. It was not until 1879 that Sydney Gilchrist Thomas, an Englishman, discovered the process which bears his name, by which ores rich in phosphorus could be used in the manufacture of steel. Since that time it has been largely employed in England and on the Continent, and more than 19,000,000 tons of steel have been produced by it. Further than this, a valuable fertilizing material is obtained as a by-product, the slag containing, on the average, 25% of phosphoric acid.

The essential principle of this method, the employment of a basic (dolomite or magnesia) lining in the steel-producing vessel, has also been applied to the open-hearth furnace. Both these processes, the Thomas (basic Bessemer) and the basic open-hearth, are used on a very large scale in England, France, and Germany. In the United States only one Thomas steel plant has ever been successfully operated, —that of the Pottstown Iron Company, Pottstown, Pa.,*—and to within very recent years the basic open-hearth process was in a similar languishing condition. The first Thomas steel in the United States was made by the Pennsylvania Steel Company at Steelton, Pa., in 1884. It was an experiment, and the project was abandoned. In 1888 the Pottstown Iron Company began the manufacture of Thomas steel.

The first commercial production of basic open-hearth steel in the United States was at the Homestead Steel Works of Carnegie, Phipps & Co., Limited, near Pittsburg, Pa., in March, 1888. In February of the same year basic open-hearth steel was made in a three-ton Henderson furnace by the Henderson Steel Company, Birmingham, Ala., and during the year 80 tons were made.

The enterprise at Birmingham was not successful financially, although 2130 tons of good steel were made before the works were finally closed down in 1890. They have recently been started again as the Jefferson Steel Company, and are now using the pig and ore process in a Siemens-Martin fifty-ton furnace lined with magnesia bricks. In Pennsylvania the industry begun in 1888 has been carried on steadily, and is now being extended in a gratifying manner.

The total output of basic open-hearth steel since 1888 has been about 500,000 tons. There are now six basic open-hearth works in this country. Some other kinds of steel are made in the United States, as Robert-Bessemer, Clapp-Griffiths, and Duplex, but the separate quantities are not available.

The first basic Bessemer or Thomas steel made in the southern district was at the works of the Southern Iron Company, Chattanooga, Tenn., in August 1891, but the industry has not been developed commercially.

* This company was placed in the hands of a receiver January 30, 1893.

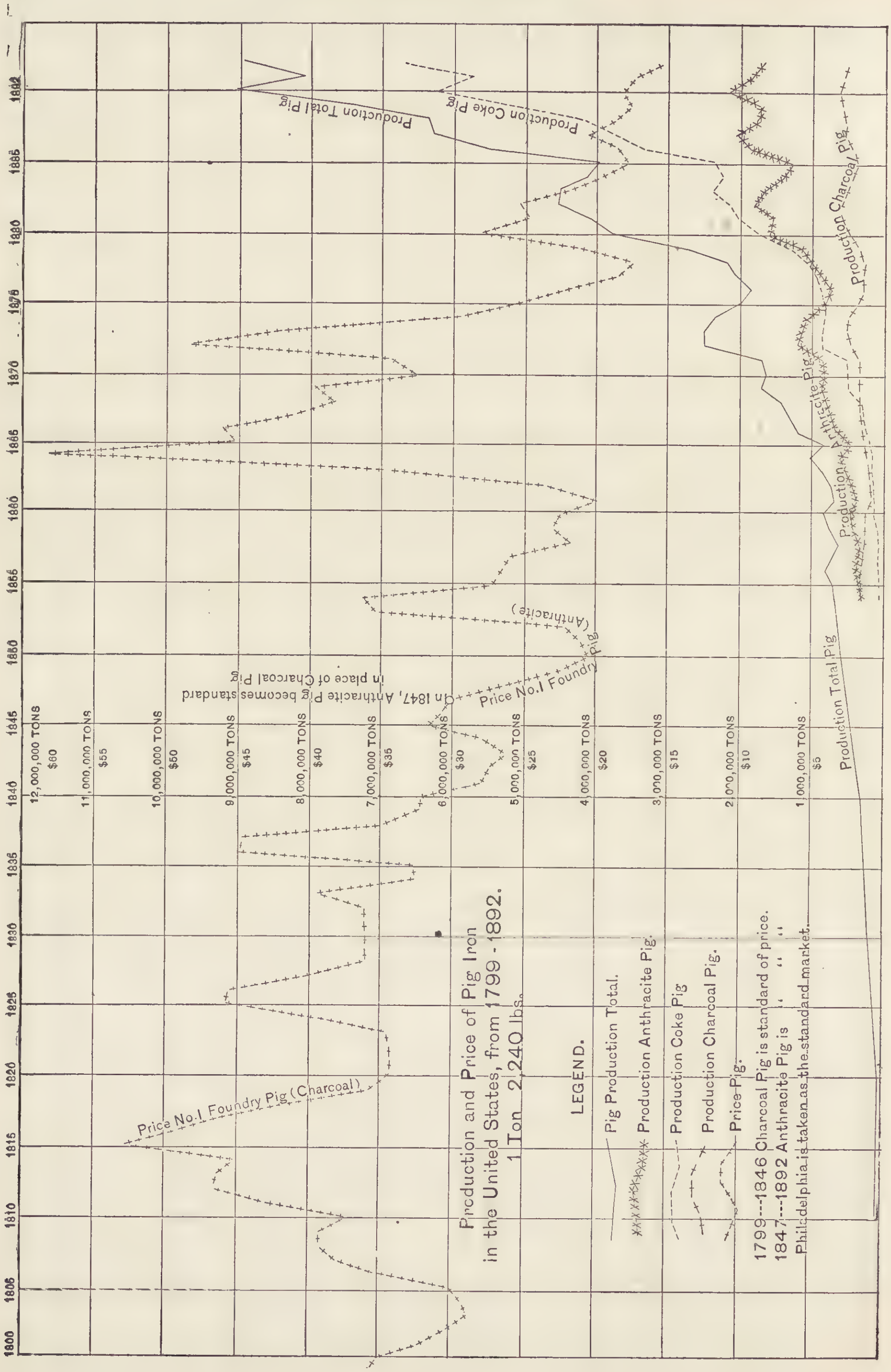
An enterprise which has been begun within recent years in this country is the American Pig-iron Storage-warrant Company. It was organized in 1889 to furnish iron-masters with a convenient means of tiding over depressions in the market. It was modeled in great measure on the system so long in use in England known as the Scotch warrant system. The movement of pig-iron in the yards of the American company is shown in the following table, which embraces all the iron it has held since its organization:

MOVEMENT OF PIG-IRON IN YARDS OF THE AMERICAN PIG-IRON STORAGE-WARRANT COMPANY FROM ITS ORGANIZATION IN 1889 TO THE CLOSE OF 1892.

Year.	Received.	Delivered.	In Yard.	Year.	Received.	Delivered.	In Yard.
1889	36,500	300	36,200	1892	105,900	26,200	79,700
1890	83,000	18,800	64,200				
1891	90,500	38,600	51,900	Total	315,900	83,900	232,000

PRICES PER TON OF STANDARD ARTICLES OF IRON AND STEEL IN THE UNITED STATES, 1794 TO 1892.

Years.	Charcoal Pig-iron.	Hammered Bar-iron.	Years.	No. 1 Anthracite Foundry Pig-iron.	Best Refined Rolled Bar-iron.	Iron Rails.	Steel Rails.	Cut Nails per Keg of 100 Lbs.
1794	...	$77.50	1837	...	...	...	...	$6.00
1795	...	82.50	1838	...	...	...	...	6.00
1796	...	106.50	1839	...	...	...	...	6.12
1797	...	101.50	1840	...	...	...	...	5.50
1798	...	97.50	1841	...	...	...	...	5.25
1799	$36.25	98.50	1842	$25.60	...	...	...	4.75
1800	35.75	100.50	1843	...	...	...	...	4.25
1801	32.75	117.50	1844	25.75	$85.62	...	...	4.50
1802	30.75	99.00	1845	29.25	93.75	...	...	4.75
1803	29.25	97.50	1846	27.88	91.66	...	...	4.50
1804	29.75	98.50	1847	30.25	86.04	$69.00	...	4.50
1805	30.75	101.00	1848	26.50	79.33	62.25	...	4.25
1806	35.75	108.50	1849	22.75	67.50	53.88	...	4.00
1807	38.75	110.50	1850	20.88	59.54	47.88	...	3.71
1808	40.00	104.00	1851	21.38	54.66	45.63	...	3.28
1809	40.00	107.50	1852	22.63	58.79	48.38	...	3.13
1810	38.00	108.00	1853	36.12	83.50	77.25	...	4.85
1811	44.00	105.00	1854	36.88	91.33	80.13	...	4.76
1812	47.50	106.00	1855	27.75	74.58	62.88	...	4.10
1813	47.25	106.00	1856	27.12	73.75	64.38	...	3.92
1814	46.00	133.00	1857	26.38	71.04	64.25	...	3.72
1815	53.75	144.50	1858	22.25	62.29	50.00	...	3.53
1816	50.25	127.00	1859	23.38	60.00	49.38	...	3.86
1817	47.00	114.00	1860	22.75	58.75	48.00	...	3.13
1818	42.25	110.00	1861	20.25	60.83	42.38	...	2.75
1819	36.50	110.00	1862	23.88	70.42	41.75	...	3.47
1820	35.00	103.50	1863	35.25	91.04	76.88	...	5.13
1821	35.00	90.50	1864	59.25	146.46	126.00	...	7.85
1822	35.00	94.50	1865	46.12	106.38	98.63	...	7.08
1823	35.25	90.00	1866	46.88	98.13	86.75	...	6.97
1824	40.00	82.50	1867	44.12	87.08	83.13	$166.00	5.92
1825	46.75	97.50	1868	39.25	85.63	78.88	158.50	5.17
1826	46.50	101.50	1869	40.63	81.66	77.25	132.25	4.87
1827	39.25	100.00	1870	33.25	78.96	72.25	106.75	4.40
1828	35.00	100.00	1871	35.12	78.54	70.38	102.50	4.52
1829	35.00	97.00	1872	48.88	97.63	85.13	112.00	5.46
1830	35 00	87.50	1873	42.75	86.43	76.67	120.50	4.90
1831	35.00	85.00	1874	30.25	67.95	58.75	94.25	3.99
1832	35.00	85.00	1875	25.50	60.85	47.75	68.75	3.42
1833	38.25	82.50	1876	22.25	52.08	41.25	59.25	2.98
1834	30.25	82.50	1877	18.88	45.55	35.25	45.50	2.57
1835	30.25	81.50	1878	17.63	44.24	33.75	42.25	2.31
1836	41.50	100.00	1879	21.50	51.85	41.25	48.25	2.69
1837	41.25	111.00	1880	28.50	60.38	49.25	67.50	3.68
1838	32.25	93.50	1881	25.12	58.05	47.13	61.13	3.09
1839	30.00	96.50	1882	25.75	61.41	45.50	48.50	3.47
1840	32.75	90.00	1883	22.38	50.30	...	37.75	3.06
1841	28.50	85.00	1884	19.88	44.05	...	30.75	2.39
1842	28.00	83.50	1885	18.00	40.32	...	28.50	2.33
1843	26.75	77.50	1886	18.71	43.12	...	34.50	2.27
1844	28.25	75.00	1887	20.92	49.37	...	37.08	2.30
1845	32.25	...	1888	18.88	44.99	...	29.83	2.03
1846	31.25	...	1889	17.75	43.40	...	29.25	2.00
1847	31.50	...	1890	18.40	45.92	...	31.75	2.00
1848	28.50	...	1891	17.50	42.40	...	30.00	1.58
1849	24.50	...	1892	15.50	41.40	...	30.00	1.53


Production and Price of Pig Iron
in the United States, from 1799 - 1892.
1 Ton 2,240 lbs.
LEGEND.
Pig Production Total.
Production Anthracite Pig.
Production Coke Pig
Production Charcoal Pig.
Price Pig.
1799---1846 Charcoal Pig is standard of price.
1847---1892 Anthracite Pig is " " "
Philadelphia is taken as the standard market.
Price No. I Foundry Pig (Charcoal)
Price No. I Foundry Pig (Anthracite)
In 1847, Anthracite Pig becomes standard in place of Charcoal Pig
Production Total Pig
Production Coke Pig
Production Anthracite Pig
Production Charcoal Pig
12,000,000 TONS
$60
11,000,000 TONS
$55
10,000,000 TONS
$50
9,000,000 TONS
$45
8,000,000 TONS
$40
7,000,000 TONS
$35
6,000,000 TONS
$30
5,000,000 TONS
$25
4,000,000 TONS
$20
3,000,000 TONS
$15
2,000,000 TONS
$10
1,000,000 TONS
$5
1800
1805
1810
1815
1820
1825
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1835
1840
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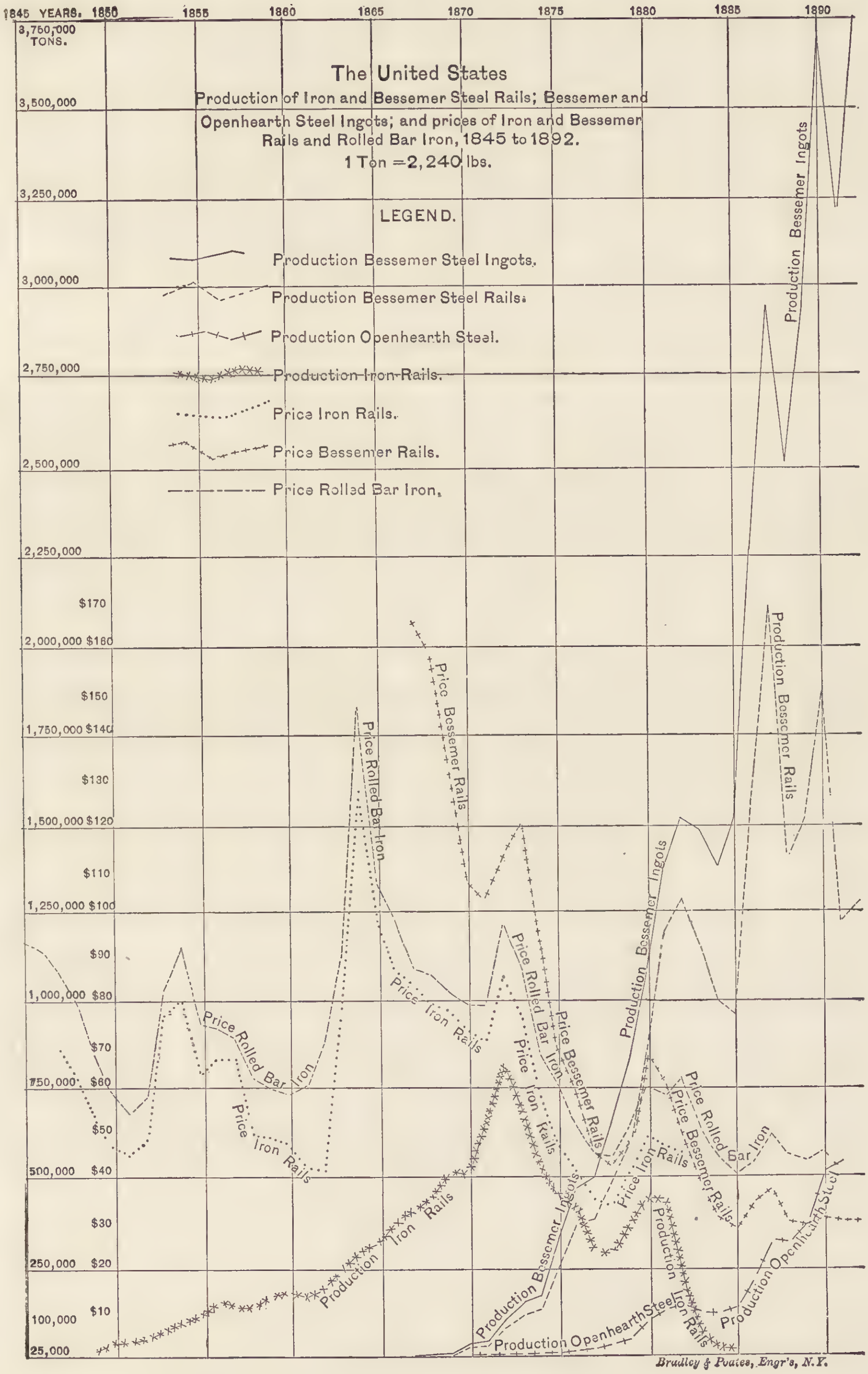
1870
1875
1880
1885
1892



Bradley & Poates, Engr's, N.Y.

The sources of information which have been consulted in the preparation of this article are the very full and excellent reports of the American Iron and Steel Association; of Mr. John Birkinbine, special agent of the Eleventh Census for iron ores; of Dr. David T. Day, Chief of the Department of Mineral Resources, United States Geological Survey; of the United States Labor Bureau; of the United States Treasury Department; and of the Census Bureau. In particular, also, I desire to express my acknowledgments to Robert J. Devenish and Edward Walker, civil engineers, for much valuable assistance in the preparation of the tables and diagrams; and to James M. Swank, who, in his *Iron in All Ages,* has contributed more than any one else in this country to the history of our iron and steel industries.

IRON ORE IN THE UNITED STATES.

PRODUCTION, VALUE AND CAPITAL INVESTED—1 TON=2,240 LBS. 10TH CENSUS, 1880.

	Mines Producing	Tons per operation.	Amount produced, Tons,					Value.		Capital Invested.	
			Brown Hem.	Red Hem.	Magnetite.	Carbonate.	Total.	Per ton. $	Total. $	Per ton. $	Total. $
Alabama............	17	9,669	98,836	67,159	......	5,144	171,139	1.18	201,865	3.13	536,442
Conn., Me. & Mass..	14	6,610	92,549	......	......	......	92,549	4.14	382,929	7.66	708,800
Del. & Md...........	15	3,611	60,255	909	194	65,743	127,101	3.37	428,244	4.24	538,814
Ga. & N. C.	16	4,240	39,934	42,148	2,501	......	84,583	1.76	148,907	2.18	184,225
Indiana..............	..	....	458	......	......	......	458	2.22	1,018	.....	....
Kentucky..........	5	5,986	15,768	... ..	......	42,097	57,865	2.87	165,905	13.48	779,829
Michigan...........	43	38,158	294,550	1,213,478	132,785	......	1,640,814	3.68	6,034,648	10.66	17,496,775
Missouri......... ...	48	7,184	100	344,718	......	......	344,818	4.86	1,674,875	16.23	5,598,556
New Jersey.........	109	6,185	13,847	......	662,378	......	676,225	4.30	2,910,442	9.17	6,201,761
New York..........	78	14,191	138,275	160,899	827,725	......	1,126,900	3.24	3,654,872	7.33	8,263,139
Ohio	30	5,918	......	......	......	488,750	488,750	2.60	1,269,530	2.59	1,248,725
Oregon....	1	6,225	6,225	......	. ....		6,225	0.67	4,669	2.72	16,975
Pennsylvania.......	358	4,540	1,009,550	267,572	498,146	176,227	1,951,495	2.83	5,517,079	9.03	17,621,701
Tennessee...........	34	2,361	24,914	68,358	......	......	93,272	1.58	147,181	5.08	473,920
Texas................	..	....	3,214	......	......	......	3,214	2.52	8,100	.....	....
Va. & W. Va........	34	6,043	118,146	43,250	10,544	45,507	217,444	2.44	530,943	8.85	1,924,625
Vermont............	1	500	......	500	......	......	500	5.50	2,750	.....	....
Wisconsin...........	2	18,500	2,000	35,000	......	......	37,000	1.97	73,000	5.03	186.000
Total and average	805	7,836	1,918,622	2,243,992	2,134,276	823,471	7,120,361	3.25	23,156,957	7.16	61,780,287

11TH CENSUS, 1890.

	Mines Producing	Tons per operation.	Brown Hem.	Red Hem.	Magnetite.	Carbonate.	Total.	Per ton. $	Total. $	Per ton. $	Total. $
Alabama............	45	34,896	379,334	1,190,985	......	......	1,570,319	0.96	1,511,611	3.34	5,244,906
Colorado.	18	6,063	100,421	4,821	3,894	......	109,136	4.47	487,433	22.73	2,480,445
Conn. Me. & Mass...	7	12,607	88,251	......	......	......	88,251	3.01	265,901	6.25	551,365
Del. & Md...........	14	2,099	18,061	......	......	11,319	29,380	2.32	68,240	12.09	355,074
Ga. & N. C..........	17	15,185	235,057	12,963	10,125	......	258,145	1.29	334,025	6.33	1,634,434
Id. & Mon...........	7	3,439	10,479	12,089	1,504	......	24,072	6.60	158,974	14.24	342,879
Kentucky...........	4	19,372	25,212	......	......	52,275	77,487	1.75	135,559	5.24	405,868
Michigan............	73	80,221	332,257	5,272,915	250,997	......	5,856,169	2.70	15,800,521	7.16	41,958,571
Minnesota...........	4	216,127	......	864,508	......	......	864,508	2.87	2,478,041	9.81	8,481,282
Missouri.............	8	33,215	400	265,318	......	......	265,718	2.11	561,041	17.36	4,613,396
New Jersey.........	24	17,313	......	......	415,510	......	415,510	3.23	1.341,543	7.62	3,168,891
N. Mexico & U. T..	2	18,025	4,033	2,017	30,000	......	36,050	1.97	70,956	4.22	152,000
New York...........	35	35,644	30,374	224,438	927,269	65,456	1,247,537	2.49	3,100,216	10.01	12,489,481
Ohio..................	70	3,633	......	......	......	254,294	254,294	2.09	532,725	5.16	1,311,918
Ore. & Wash.	3	8,761	26,283	......	......	......	26,283	1.49	39,234	3.29	86,285
Pennsylvania........	189	8,255	496,555	162,957	860,916	39,806	1,560,234	1.96	3,063,534	10.41	16,249,313
Tennessee............	16	29,581	174,192	299,102	......	......	473,294	1.28	606,476	4.01	1,897,895
Texas............ ..	2	6,500	13,000	......	......	......	13,000	1.52	19,750	3.97	51,678
Va. & W. Va.......	38	13,454	487,208	8,746	6,200	9,101	511,255	1.83	935,290	7.64	3,905,249
Wisconsin...........	16	52,337	101,970	735,429	......	......	837,399	2.20	1,840,908	5.24	4,385,269
Total and average..	685	24,524	2,523,087	9,056,288	2,506,415	432,251	14,518,041	2.30	33,351,978	8.30	109,766,199

SPECIAL IRON ORE VESSELS ON THE GREAT LAKES.

Owners.	Number of Vessels.	Capacity of Vessels.	Total Capacity.
Minnesota Iron Company	8	2,300–3,000	19,800
Menominee Transit Company	6	2,900	17,400
Lake Superior Iron Company	6	2,300-2,500	14,400
Cleveland Cliffs Company	4	1,800–3,000	9,800
Republic Iron Company	5	1,200–2,500	9,200
Cleveland Rolling Mill Company	4	2,000-2,700	9,150
Total	33	....	79,750

DIMENSIONS OF SHIPPING DOCKS FOR LAKE SUPERIOR IRON ORES.

Location.	Height of Dock, Ft.	Length of Dock, Ft.	Number of Pockets.	Capacity, Long Tons.	Number of Railroad Tracks.
Marquette, Mich., No. 1	45	1,800	270	30,000	4
" " " 3	44	1,600	300	25,000	3
" " " 4	47½	1,400	200	30,000	4
St. Ignace, Mich	42	400	50	7,000	3
L'Anse, Mich	38	1,000	100	8,000	....
Escanaba, Mich., No 1	46	1,104	184	23,000	2
" " " 2	39	1,082	192	19,300	2
" " " 3	39	1,212	202	20,000	2
" " " 4	46	1,500	250	33,200	2
" " " 5	51⅝	1,392	232	40,600	2
Gladstone, Mich	47	.. ...	120	16,000	5
Two Harbors, Minn., No. 1	47	1,056	162	55,000	2
" " " 2	46	1,056	141		2
" " " 4	51½	528	84		4
Ashland, Wis., No. 1	40	1,404	234	23,000	4
" " " 2	45	1,404	234	27,000	3
" "	46	1,404	234	28,250	3
Total	....	19,342	3,189	385,350	47

OUTPUT OF IRON ORE BY STATES AND KINDS IN 1891.

Tons of 2240 lbs.

	Brown Hem.	Red Hem.	Magnetite.	Carbonate.	Total.
Alabama	462,047	1,524,783	....	....	1,986,830
Colorado	99,253	6,940	4,749	....	110,942
Connecticut	30,923	....	....	....	30,923
Georgia	205,728	45,027	....	....	250,755
Idaho	400	....	....	....	400
Kentucky	45,111	....	....	19,978	65,089
Maryland	19,400	....	....	17,979	37,379
Massachusetts	47,502	....	......	....	47,502
Michigan	457,507	5,445,371	224,123	....	6,127,101
Minnesota	....	945,105	....	....	945,105
Missouri	7,431	99,518	....	....	106,949
Montana	4,000	8,536	....	....	12,536
New Jersey	3,840	3,850	517,922	....	525,612
New Mexico	1,000	....	38,776	....	39,776
New York	53,152	153,773	782,729	27,612	1,017,216
North Carolina	....	....	19,210	....	19,210
Ohio	....	....	....	104,487	104,487
Oregon	29,018	....	....	....	29,018
Pennsylvania	363,894	162,683	727,299	19,052	1,272,928
Tennessee	147,040	396,883	....	....	543,923
Texas	51,000	....	....	....	51,000
Utah	8,000	4,000	....	....	12 000
Virginia	653,342	3,272	2,300	....	658,916
West Virginia	6,200	....	....	....	6,200
Wisconsin	61,776	527,705	....	....	589,483
Total	2,757,564	9,327,398	2,317,108	189,108	14,591,178

WEEKLY PRICES PER TON OF PIG-IRON, NEUTRAL MUCK BAR, STEEL BILLETS AND SLABS, OLD IRON AND STEEL RAILS, AND BESSEMER ORE, AT PITTSBURG DURING 1892.

	Pig-iron.				Neutral Muck Bar.	Steel Billets and Slabs.	Old Rails.		Bessemer Ore on Wharf, Cleveland.	
	Gray Forge.	No. 1 Foundry Coke.	Charcoal Cold-blast.	Bessemer.			Iron.	Steel.	Amount Sold, Tons.	Price per Ton.
	$	$	$	$	$	$	$	$		$
Jan. 7	13.50-13.75	15.50-16.00	25.50-26.50	15.75-16.00	25.75-26.00	25.00-26.00	23.00	17.50	38,000	4.50
14	13.35-13.50	15.50-16.25	25.00-27.00	15.65-15.90	26.00	25.00-26.00	23.50	17.50	5,000	4.50
21	13.45-13.50	15.50-16.00	25.50-26.75	15.60-15.75	26.00	25.00-25.25	22.00	18.00	3,300,000	4.50-5
28	13.40-13.50	15.75-16.00	25.50-26.50	15.50-15.60	25.75-26.00	24.75-25.40	22.50	17.50	2,310,000	4.75-5
Feb. 4	13.30-13.35	15.75	25.50-26.75	15.25-15.50	25.50-25.65	24.50-25.00	22.00	17.25	......	......
11	13.25-13.30	15.50	26.00-26.75	15.25-15.50	25.60	25.00	22.75	17.25	......	......
18	13.25-13.50	15.50	25.50-26.50	15.00-15.25	25.50	23.20-24.50	22.75	17.25	......	......
25	13.00-13.25	15.75	25.50-26.75	14.75-15.00	25.50	23.00-24.00	22.50	17.25	......	......
Mar. 3	13.00	15.50	26.50	14.75-15.00	25.25-25.50	23.00-23.50	22.25	17.00	......	......
10	13.00	15.50	25.50-26.50	14.50-15.00	25.25-25.50	23.00-23.25	22.25	16.75	......	......
17	12.75-12.85	15.50	26.50	14.50-14.85	25.40-25.50	22.87-23.25	22.25	16.50	......	......
24	12.80-13.00	15.25	26.50	14.50-14.75	25.50-26.25	22.75-23.75	21.75	16.25	......	......
31	12.80-13.00	15.25	26.00-26.50	14.50-14.75	25.15-25.25	23.00-23.50	21.75	16.25	......	......
April 7	12.95-13.00	15.50	26.50	14.50-14.60	25.00-25.40	23.00-23.40	21.50	16.00	......	......
14	12.85-13.00	15.25	26.50-26.75	14.50-14.60	25.00-25.60	23.00-23.25	21.50	16.00	......	......
21	12.90-13.00	15.25	26.00-27.00	14.40-14.50	25.00-25.25	22.70-23.25	21.40	15.50	40,000	4.00
28	12.85-13.00	15.50	26.75	14.40-14.50	25.00-25.10	22.75-23.25	21.25	16.00	......	......
May 5	12.85-13.00	15.25	26.50-26.75	14.25-14.50	25.00-25.25	22.35-22.80	21.00	16.00	......	......
12	12.80-13.00	15.25	26.50-26.75	14.25-14.50	25.00	22.50-23.00	20.50	15.50	15,000	4.10
19	12.80-13.00	15.25	25.50	14.25-14.30	24.75-25.00	22.35-22.50	20.25	15.50	......	......
26	12.75-13.00	15.25	26.00-26.50	14.20-14.25	24.80-25.00	22.35-22.50	20.50	15.50	......	......
June 2	12.75-13.00	15.00	26.50-26.75	14.10-14.25	24.65-25.00	22.50-22.60	20.25	15.25	......	......
9	12.75	15.25	24.00-26.50	14.00-14.25	24.75-25.00	22.45-23.25	20.50	15.35	6,500	4.25
16	12.75-12.90	15.00	26.00-26.75	14.00-14.10	24.75-25.00	22.50-23.40	20.00	15.25	......	......
23	12.65-12.75	15.00	26.00-26.50	14.00-14.15	24.75-24.85	23.25-24.00	20.00	15.25	21,500	4.00
30	12.65-12.75	15.00	26.00-26.50	14.00-14.15	24.75	23.00-23.85	20.00	15.50	......	......
July 7	12.75	15.00	26.00	14.00-14.10	24.75	23.00-23.25	20.00	15.50	......	......
14	12.75	15.00	26.50-26.75	14.00-14.10	24.70-24.75	23.25-24.10	19.75	15.50	......	......
21	12.75	14.75	26.50-26.75	13.85-14.00	24.75	23.00-24.00	19.75	15.40	......	......
28	12.75	14.75	26.50	13.90-14.00	24.65-24.75	23.50-25.00	19.50	15.25	......	......
Aug. 4	12.75	14.75	26.50	14.00	24.75-25.0	24.00-25.00	19.75	15.75	......	......
11	12.75	14.75	26.50	14.00	24.75-25.0	23.25-25.00	19.00	15.50	......	......
18	12.50	14.75	24.00-26.00	14.00	24.75-25.00	23.25-24.50	19.25	15.25	......	......
25	12.50	14.50	26.00	13.90-14.00	24.80-25.00	23.75-24.75	19.00	15.00	......	......
Sept. 1	12.50	14.50	26.00-26.50	13.85-14.00	24.75-25.00	23.50-24.00	19.25	15.50	......	......
8	12.50	14.50	26.00-26.50	13.85-13.90	24.50-25.00	23.50-24.50	19.50	15.00	......	......
15	12.50	14.50	25.50-26.50	13.75-13.85	24.85-25.00	23.75-24.25	19.60	15.50	......	......
22	12.50	14.50	24.00-26.50	13.85-14.00	24.75-24.90	23.00-24.25	19.75	15.50	3,000	5.25
29	12.50	14.75	25.00	13.70-14.00	24.75-25.00	22.40-23.50	20.50	15.45	13,000	4.00
Oct. 6	12.50	14.50	26.00	13.80-14.00	24.60-24.75	22.00-23.62	20.75	15.50	......	......
13	12.50	14.50	25.00-26.50	13.70-14.00	24.50-24.75	22.60-24.00	20.50	15.25	......	......
20	12.50	14.50	25.00-26.00	13.75	24.60-24.75	23.00-24.50	20.50	16.00	......	......
27	12.50	14.50	26.00-26.50	13.90-14.00	24.50-25.00	24.00-25.00	20.50	16.00	......	......
Nov. 3	12.50	14.50	26.50	14.00-14.10	24.62-25.00	23.50-25.00	20.00	16.50	......	......
10	12.50	14.50	25.00-26 00	14.00	24.75-25.00	23.50-24.50	20.15	16.50	......	......
17	12.50	14.50	26.00	13.80-14.00	24.75-24.85	23.75-24.50	20.10	16.00	......	......
24	12.50	14.50	26.00-26.50	14.10-14.25	24.75-24.85	24.00-25.00	20.00	16.00	......	......
Dec. 1	12 50	14.50	25.50-26.50	14.00-14.25	24.70	23.50-24.50	20.00	16.00	......	......
8	12.50	14.50	24.00-26.00	13.90-14.25	24.50-24.75	22.75-24.00	20.50	15.35	......	......
15	12.50	14.50	26.00-26.50	13.75-14.00	24.65-24.75	22.00-23.50	20.50	15.25	......	......
22	12.50	14.25-15.00	26.00-26.50	13.75-13.85	24.65-24.70	22.00-23.50	20.50	15.25	......	......
29	12.50	14.25-15.00	26.00-26.50	13.70-13.75	24.50-24.60	22.00-22.25	21.00	16.00	......	......
Totals	12.80	14.97	26.12	14.24	25.00	24.10	20.76	15.98	5,752,000	4.0-5.25

Buffalo Pig-iron Market in 1892.

Whatever may be the future of the pig-iron industry, the year 1892 will stand out as a prominent landmark in its history. The year just closing is either the first of a long line of years whose record will demonstrate that the United States is destined to be not only the largest but the cheapest producer of pig-iron in the world, or it will stand out unique and unparalleled.

At the opening of the year, prices of Lake Superior coke irons were as low as they had ever touched, but even then sales were very much curtailed by the large amount of Alabama and Tennessee irons which, notwithstanding the heavy freight, were replacing them.

As is well known, production through the year, except possibly during the last quarter, has exceeded consumption. This situation precipitated a warfare between Southern and Northern furnaces, resulting in a steady decline in prices both North and South, until in August iron could be bought in Birmingham, Ala., at $10 per ton less than the same grade could be obtained in Middlesborough, England. During this struggle, furnaces North and South were able to reduce cost of manufacture. In some cases in the South it is said to cost $1 per ton less to make a ton of pig-iron than in 1891. The outcome was that the Southern furnaces sold all their "make" for this year and for January and February of 1893 before they commenced to advance prices in September. Southern competition at this time being somewhat removed, Northern iron commenced to move a little more rapidly, although at unchanged prices.

With the decreased demand of December to be followed by the inventorying month of January, we enter 1893 in practically the same condition as in January, 1892, but with prices $1 per ton lower.

No. IX. strong Lake Superior coke iron was selling in January, 1892, for $16.25, and in December, 1892, for $15.25, both cash, free on board cars at Buffalo.

Prices of Lake Superior charcoal iron touched an unprecedented figure during the year. Some sales were reported as low as $15 cash, free on board cars at Buffalo, although the more popular irons would not shade $16.

Review of the Chicago Iron Market for 1892.

The year just closed has been a rather momentous one to the iron trade in Chicago and vicinity, opening as it did in January with a bright prospect and unshaken confidence in all branches. It rarely happens that prices have shown so little change, but the tendency since February has been steadily downward in both Northern and Southern crude iron of all kinds and grades. The output, too, during the earlier months was enormous, but a steady curtailment has taken place since March. The whole country was only just recovering

from the shock of the Baring failure, and prosperity, to all appearances, was once more secured. Values at the outset seemed to be on a firmer basis, with a fair chance of affording some return on the capital invested. The previous year (1891) had been a trying and unprofitable one to manufacturers, and high hopes were generally entertained that 1892 would enable them to recoup themselves. The first surprise was the break in the steel-beam combination at the end of January after an existence of two years. This had a depressing effect on the market, and was severely felt in some quarters. The location of the World's Fair here has proved a potent magnet to capitalists, and vast sums have been spent in the extension of old plants and the erection of new industries and enterprises in and for the manufacture of iron and steel, especially the latter. This gave an impetus to the production of iron ore, and the output from the Lake Superior regions will eclipse the record of 1890. Particular interest is shown in the steady rise and development of soft steel, which only a short time ago was an infant struggling for existence. The steel-rail market, which was active early in the year, has dwindled down to a condition bordering on apathy. The demand for manufactured iron has been fair only, but the great strikes and lockouts in Pennsylvania and northeastern Ohio in July and August greatly stimulated these industries in this vicinity. The characteristics of this market during the latter half of the year were enormous consumptive capacity, large volume of trade, and low prices of iron and steel.

Pig-iron.—With an outward semblance of strength during the initial month of the year, the trend of the market has been steadily downward—this, too, not only on Southern but on Northern iron as well. The chief cause was the heavy production, largely in excess of even the great consumption. Stocks in the South exceeded 900,000 tons, but by the steady reduction in output by the blowing out of furnaces less advantageously situated the stocks have been reduced to about 600,000 tons. Further restriction, however, will be necessary. As to prices, local coke iron has receded from $1 to $1.25 per ton, and Lake Superior charcoal iron about the same. The fluctuations have been slight either way. Southern coke iron, however, shows a greater decline on the cheaper grades. No. 1 foundry in January was quoted at $15.50 and in December at $14.25, and No. 1 soft for the same months $15.25 and $13.75—a drop of $1.50. Demand from implement-makers has been very large for coke and charcoal iron, as they were completely sold out of stock during the autumn of 1891, owing to the immense small-grain crop throughout the West and Northwest. A marked decline in demand was noticed during the last six weeks of the year. The market just now shows an evident lack of confidence as regards the future; not that any serious change is expected, but a number of new enterprises which had been contemplated have been postponed for the time being.

Structural Iron and Steel.—The collapse of the Beam Association brought values to a lower basis, from $3.20 to $2.20, and stimulated the already active market. The building boom of this year outside of the World's Fair has been exceeded once only—the year immediately succeeding the great fire in 1871. Bridge and viaduct work has been active. The Carnegie trouble caused a big advance in structural material. The year closes with a good inquiry.

Steel Billets and Rods.—The product of the steel-mills here has been well sold

up for the whole year, and quotations have been remarkably steady on both of these specialties, but are low now.

Plates.—Early in the year demand was entirely of a routine character, but steadily enlarged until the boiler-makers' strike in May, which lasted some months and greatly crippled that industry locally. The men lost the fight and business is now normal. This class of material is also on a lower basis than early in the year.

Merchant Steel.—Demand during the whole year has exceeded even the highest expectations of manufacturers, and the year 1892 has been the banner year for manufacturers of soft steels for agricultural-implement makers. The local mills claim to be sold up to July 1, 1893, and are out of the market except for small quantities, such as may be added to existing contracts. Bessemer bars have declined 25% during the year.

Bar Iron.—Demand has been from fair to active up to the strike in Pennsylvania. The mills in this vicinity, being unaffected, were active, and demand for a short time was in excess of supply at fairly remunerative prices. Another mill was recently started, and another and larger concern at Cummings, South Chicago, will commence rolling iron in January. The fluctuations in values have not exceeded 75c. a ton throughout the year—$1.67½ in January and $1.60 in December.

Black and Galvanized Sheets.—Demand from roofers, corrugators, and other large consumers has been exceedingly large, owing to the big increase in building operations. Galvanized iron has been especially active all through the year, and during the latter part mills were unable to supply the trade with any degree of promptness. Quotations on both have been remarkably steady, the variations at the opening and the close of the year being merely nominal.

Nails.—The popularity of the wire nail is the chief feature of the nail market. Improvements in methods of manufacture have brought the value to a parity with that of steel-cut, and mill quotations on each are about the same, though at the beginning of the year there was a difference of 20c. a keg. Demand has been large for both, but particularly for wire nails.

Steel Rails.—The steel-rail situation is peculiar. The tonnage placed last winter, 1891–92, was very large, and orders were frequent and for good round lots during the first half of the year, but during the latter part and up to this writing, in the last week of December, there has been a strange absence of demand. To be sure, railroad managers have been giving a large amount of attention to the improvement of mileage already constructed, but important extensions planned months ago have been postponed until next year. Hence the demand has partaken of a hand-to-mouth character for several months. The outlook for the coming spring and summer is regarded as propitious. The Colorado steel-mills will of necessity absorb a large share of the far-Western patronage, until recently enjoyed by the local mills. Owing to the integrity of the Rail Association, quotations have been steady throughout the year.

Old Material and Scrap.—Old iron rails have receded during the year fully $4 a ton, attributable in a large degree to the displacement of iron by steel in the manufacture of splice bars, and to the establishment of puddling furnaces when rails were scarce. In January they were selling at $22, and are now quoted

at $18@$18.50, and are sold at less than $18. Old steel rails have also declined from $14 to $12.50, and demand has been light. Old wheels have shown a retrograde movement both in demand and value, the latter being about a ton since January. Scrap iron and steel have been in very moderate demand throughout the year, and prices have steadily gone down, ranging from $1 to $3 a ton, according to quality and grade.

Review of the Louisville Iron Market in 1892.

Hall Bros. & Co.

Most of the year has been so marked in one direction as to leave but little to be said on the subject. In reviewing the situation we find that the general features and tendencies of the market have been very similar to those of 1891. Prices have declined a shade more in this than in the previous year up to about ninety days ago, when there were signs of revival, and an active buying movement set in, which created a strong market and advanced prices, drawing largely upon the output of the furnaces for forward delivery, and also upon accumulated stocks, diminishing the latter to a very appreciable extent.

While prices were on the decline they reached the lowest ever recorded. In January the current quotation on gray forge was about $9.50 Birmingham, but in February extreme quietness prevailed and concessions were offered. In March gray forge was reported about $9.25, and other grades proportionately; stocks in first hands were heavy about this time, and increasing. April and May were rather uneventful, and the market was dull and drooping. The outlook in June was not promising, buyers still pursuing the hand-to-mouth policy, gray forge ranging as low as $8.25. Inquiries were made for round lots, but resulted in small purchases. The unsettled condition of labor troubles at Homestead added weight to the depression, and only a few important orders were placed. At about this time some astonishingly low figures were made, not alone by weak companies of urgent wants, who could not afford to carry heavy stocks, but by the stronger companies as well.

About August the market became so unsettled that even special concessions did not help business, inducements being used simply to pull prices down further. In September sales materially increased. Encouraged by heavy reductions in stocks, a better tone pervaded the market, and there was talk of higher values, strong efforts being made to secure advanced prices for forward delivery. In October buying became still more liberal and increased prices were obtained; there was a marked disposition on the part of some companies to crowd up prices. The consuming trade became actively employed on orders for finished goods at better prices, and for a few weeks the market experienced a lively buying movement, and a large proportion of the decline for the year was regained. Fears were entertained, and so expressed, that the furnaces were over-zealous and

might crowd prices too much. This belief was based partly upon the knowledge of large speculative orders being booked, which afforded merely a temporary relief to the depressed situation, although the buying for actual consumption was abnormally large. The South took the lead in advancing prices, the North responding very conservatively to the move. Quietness has prevailed for several weeks, but it is thought that the furnaces have a sufficient amount of their product sold ahead to hold the market to about the present values for some time, and it is considered only natural that things should rule quietly now after an active period and in view of the approach of the New Year, which is stock-taking time with many.

It is interesting to review the records of prices for the past three years, which show that during almost that entire time the market has been on a decline, amounting to about $6.75 per ton in Southern coke metals, part of which has been regained by the recent advance. The market is in a fairly good condition now, but producers will do well if they can keep prices at their present level.

Review of the New York Iron Market.

Taking a retrospective view of the local market for the past three years, we find the opening price for 1889 was $18 for 1X, $17 for 2X. During the winter and early spring the stock of iron had considerably increased over the amount on hand at the beginning of the year. The Southern agents commenced to cut prices, and the Northern furnaces had to follow to keep their trade, the decline bringing the price to $16.50 and $15 for 1X and 2X. At this point consumers commenced to buy more liberally, and some contracted into 1890. The price advanced about July 1 50c. a ton, and kept firm at this until December, when it went to $18 and $17 for 1X and 2X, and some sales were made at $19 for 1X. The trade generally was considerably excited as to the opening prices for the new year. In January, 1890, the Thomas Iron Company made its prices $20 for 1X and $19 for 2X, and entered a large number of orders at these prices, the Southern irons being held at 25c. above. By April, the stocks increasing and the demand falling off, prices again receded, stopping at $18 and $17 for good Northern brands, and held at this for the rest of the year and during 1891, with about $1 less for the Southern makes. In January, 1892, the Thomas Iron Company reduced its price to $17.50 and $16, and made a further reduction in March to $16 and $15. The Southern and some of the Northern furnaces continued to press their iron for sale, and at reduced prices, so that the Thomas Iron Company made another reduction in July to $15 and $14 for 1X and 2X, which are the prices at the present time, although some brands of Southern iron are selling lower. The continued low price for the last six months is unprecedented in the iron trade, and if the past is any guide to the future some change must soon take place.

Pittsburg Iron Markets in 1892.

(From our Special Correspondent.)

The year 1892 will hereafter be known as the year of the great strike, which lasted from July to December, and involved the loss of many lives and a great deal of money. Notwithstanding this, the sales of raw iron in Pittsburg amounted to 1,990,590 tons, being only 188,914 tons below the sales of 1891, which was a year without strikes.

An important feature of the last year was the advance made by soft steel in superseding iron, and it is sold now more cheaply than iron. Steel skelp, wide-grooved, is sold at 150 four months, and iron skelp, wide-grooved, four months at 157½, a difference of 7½c. per 100 lbs. in favor of steel.

As regards the future there is a wide range of opinion. Prices for all kinds of iron and steel are down to a very low figure. No very great advance of prices is likely to occur. The fact is that many discreet producers, who are in the habit of estimating effects and results before they give countenance to ventures, object to any advance in the price of Bessemer pig metal that will carry the price higher than $14.75 to $15. They argue that these prices will pay reasonable profits, and that anything beyond legitimate returns promotes a competition that very quickly demoralizes conditions and brings depression.

The tables we present are made up from our own weekly reports of transactions. In addition we report the sales of 5,752,000 tons of iron ore, as against 4,525,000 tons in 1891. The price quoted is the price on the wharf at Cleveland or the lake ports generally.

MONTHLY SALES OF RAW IRON AND STEEL AT PITTSBURG FROM 1887–92.

(Tons of 2240 lbs.)

Month.	1887.	1888.	1889.	1890.	1891.	1892.
January	126,385	40,265	66,213	147,270	85,062	203,247
February	102,600	54,530	63,057	82,870	158,365	117,245
March	63,050	57,925	113,038	105,777	125,749	243.019
April	58,095	73,656	61,060	84,325	167.216	115.875
May	65,695	68,770	123,640	139,495	180,640	148,323
June	62,850	111,240	125,945	181,640	269,595	139,670
July	89.860	126,030	188,365	121.360	229,090	137,000
August	64,795	123,675	206.545	159,235	124,436	132,690
September	89,640	123,940	155.903	174,940	194,210	180,953
October	60,989	134,915	377,095	187,020	185,735	242,340
November	50,085	120.125	201,405	141,055	261,861	244,714
December	66,770	93,965	239,775	88.705	186.500	119,310
Total	916.974	1,109.856	1,923.056	1.595,772	2.179,504	2,024,386

MONTHLY PRICES OF PIG-IRON AT PITTSBURG, 1887–92.

Month.	1887.		1888.		1889.		1890.		1891.		1892.	
	Gray Forge	Bessemer.	Gray Forge	Bessemer.	Gray Forge.	Bessemer.	Gray Forge.	Bessemer.	Gray Forge.	Bessemer.	Gray Forge.	Bessemer.
January	$20.50	$21.50	$16.50	$19.00	$15.50	$16.65	$18.25	$24.00	$14.25	$16.25	$13.50	$15.70
February	20.00	20.50	16.25	18.50	14.50	16.50	18.00	23.00	14.50	16.50	13.30	15.20
March	19.50	23.00	16.00	18.32	14.75	16.75	17.00	20.00	15.00	16.50	12.90	14.70
April	19.50	22.00	15.50	18.25	14.25	16.50	15.25	18.25	14.25	16.50	12.95	14.50
May	19.00	22.00	15.00	17.00	14.00	16.65	15.50	18.25	14.12	16.50	12.90	14.40
June	18.25	21.00	14.30	17.00	14.00	16.00	15.75	19.25	14.15	16.25	12.80	14.10
July	18.50	21.00	14.25	17.00	14.00	16.65	15.50	19.30	14.10	15.80	12.75	14.00
August	18.50	21.50	14.25	17.25	14.50	16.85	15.50	18.75	14.00	15.80	12.60	14.00
September	18.00	20.75	16.25	18.00	15.65	18.00	15.25	18.50	14.10	15.62	12.50	13.90
October	18.00	20.50	16.50	18.00	16.25	19.00	15.25	17.75	13.87	15.40	12.50	13.90
November	17.75	20.50	16.00	18.00	16.75	21.50	15.00	17.50	13.60	15.18	12.50	14.05
December	16.75	19.50	15.50	17.25	19.00	24.00	14.75	16.75	13.50	15.25	12.50	13.90

LEAD.

THE production of lead in the United States, which rose from 162,000 short tons in 1890 to 202,000 tons in 1891, increased again in 1892 to 218,500 tons, including 26,734 tons smelted from foreign ores and 12,874 tons of Mexican bullion refined in bond and exported. Of the lead imported in ores and smelted here, all but a small quantity came from Mexico. The production of lead from domestic ores was 178,892 tons, against 178,133 tons in the previous year. Thus the immense output of 1891 was more than maintained, notwithstanding the lower prices of silver and lead, the labor troubles in Idaho, the inactivity among the silver-lead mines in Montana, and the decrease in the yield of Leadville, Colo. Such a large product as our returns show, in the face of these adverse influences, is noteworthy indeed. It proves that the lead supplies of this country are so many and so large that the demands of the market can be met easily even when the most important producers are laboring under difficulties which restrict their output. The amount of ore imported, notwithstanding the tariff, shows also that it is absolutely necessary for our smelters to secure lead ore from foreign sources in order to reduce our own silicious silver ores. The additional cost of this imported fluxing ore was, of course, paid by our silver ore miners, as is shown in the heavy increase in smelting charges, averaging about $2.50 a ton on these ores.

As an additional object lesson, we have in the amount of bullion refined "in bond" and exported an indication of what our metallurgical industry might do had it free raw materials.

PRODUCTION OF LEAD IN THE UNITED STATES.

	1890.	1891.	1892.
From domestic ores:			
Desilverized	106,980	139,033	142,087
Soft	32,000	34,000	31,000
Antimonial	4,896	5,105	5,805
Total domestic	143,876	178,138	178,892
From foreign ores	18,124	21,162	26,734
Foreign bullion refined, in bond	....	2,700	12,874
Total product of works	162,000	202,000	218,500
Imported for consumption	9,975	1,915	....
Total supply	171,975	203,915	218,500
Exported in bond	....	2,700	12,874
Stocks, of refined	....	9,000	5,500
Consumption	171,975	192,215	200,126
In white lead	....	60,000	64,800
Pipe	....	35,000	37,000
Sheet	....	12,500	13,500
Shot	....	15,000	15,000
Other uses and stock	....	69,715	75 626

The amount of antimonial lead produced as given in this table was determined from direct returns by nearly every producer in the country; it increases with the amount of argentiferous bullion which is derived from ores containing small and irregular quantities of antimony. The dross in refining bullion is allowed to accumulate until a sufficient quantity is obtained, when it is run down and sold as antimonial lead, containing from about 15% to 20% antimony. The total output may be roughly estimated to contain on an average 17%, or, in the three years for which our statistics run, as follows: in 1890, 832 tons (of 2000 pounds) antimony; in 1891, 868 tons; and in 1892, 987 tons. This is not included in our figures of the production of antimony in the United States.

Antimonial lead is used chiefly in the manufacture of anti-friction metals and in type.

Consumption of lead grows at an enormous rate, especially when the price is low. White lead continues to be the largest single use for the metal, but pipe, sheet, and shot are very important uses. We have obtained such data as enable us to estimate, for the first time and with a fair degree of accuracy, the quantity used in each of these articles during the past few years.

Stocks of Lead.—Each of the producers of refined lead, and, with few exceptions, each producer of base bullion, has made returns for the past three years of his stock of the metal on hand, sold or unsold, at the close of each year. Each succeeding year the previous year's report was checked, for heretofore the reports being made in December the statistics for that month had necessarily to be in part estimated. From these returns we are able to say that the stocks in first hands have declined about 3500 tons during the year. They are now extremely low, and, in fact, the lead has been shipped during the past year hot from the works to market; yet notwithstanding this favorable statistical position, the market has steadily declined, as shown in the accompanying table of average monthly prices in New York.

It is in the nature of a coincidence that the domestic production of lead was so nearly the same in 1891 and 1892, for in the latter year there were important changes in the relative positions of the various States. In Colorado the year was one of great activity among the silver mines, and important additions were made to many of the smelting-works; but no new large deposits of silver-lead ore were discovered, and those of Leadville made a smaller output, so that the total production of the State shows a decrease of about 2500 tons. In Leadville the Maid of Erin Silver Mines, Limited, shipped its last lot of lead carbonate ore in December, and its great reserves are now exhausted, as predicted by the *Engineering and Mining Journal* when the mine was floated in London. According to returns furnished by the smelters, 22,211 tons of lead were produced in 1892 from ore mined in Leadville. In New Mexico the large bodies of silver-lead ore at Cook's Peak were opened extensively, and heavy shipments were made from that point. The year was very prosperous in the various mining districts of southwestern Missouri and southeastern Kansas, and 24,000 tons of lead ore were shipped from that region, against 14,000 tons in 1891. The total production of lead from non-argentiferous ores increased about 3000 tons, but an important part of this was marketed as desilverized, the ores having been smelted with argentiferous ores from the West.

The product of Nevada was about the same as in the previous year, but that of Utah increased. The Eastern smelters have been compelled to draw upon this Territory more and more, to make up for the decrease in the lead supply of Colorado. In Idaho the labor troubles which had been threatening for some time finally came to a head in July, and there was a general shut-down in the Cœur d'Alêne, which lasted many weeks and caused a considerable falling off in output. This question is now settled, and the mines are producing largely again. An increased output may be expected from this region in 1893.

Early in the year it was said that the promising lead mines at Castle, Mont., had been purchased by a New York syndicate and the long-talked-of railway to that district was to be built immediately; hence an increase in yield was looked for from that direction. But the various schemes seem to have come to naught, for the mines were closed down during the spring and have remained idle since that time. The mines of the Barker and Neihart districts were also idle for several months of the year, and Montana consequently shows a decreased production.

The prospect for the future in the lead industry is for a still larger production. It is evident from the results in 1892 that neither the low price of silver now prevailing nor the low price of lead will restrict the mining of those silver and silver-lead ores which are reduced by smelting. There was a closing down of many silver mines with milling ores in 1892 on account of the low price of silver and a depression in the industry in Montana, Nevada, and Arizona; but the increase in the production of dry ores in Colorado, where nearly all of the ore mined goes to the smelters, was enormous.

The final exhaustion of the lead carbonate ore of Leadville will be felt by the smelters more severely this year, and will make a further decrease likely in the production of lead in Colorado; but the mines of the Cœur d'Alêne, Idaho, which are showing no signs of diminution with depth, can be worked at a profit even if silver goes lower than at present, and, the labor question now having been decided, they will undoubtedly make a larger yield in 1893 than in 1892.

The following table gives the production of lead in the United States and the amount imported in ores and bullion, smelted or refined here. We have also made an attempt to distribute the domestic production among the various States. The figures for the years previous to 1885 are taken from the *Mineral Resources of the United States*, 1883 and 1884. In subsequent reports the Geological Survey did not make a complete distribution of the product. The production for the years 1885–88, both inclusive, are taken from the *Mineral Resources of the United States*, with the exception of the figures which we have estimated, as indicated in the table. The distribution for the year 1889 is based on the figures of the Eleventh Census; the figures for the years 1890, 1891, and 1892 are compiled from returns which we have received directly from every smelting company in the United States.

PRODUCTION OF LEAD IN THE UNITED STATES FROM 1825 TO 1873.

(Short tons = 2000 lbs.)

Year.	Short Tons.	Year.	Short Tons.	Year.	Short Tons.	Year.	Short Tons.	Year.	Short Tons.
1825........	1,500	1838	15,000	1847..	28,000	1856.....	16.000	1865.....	14,700
1830........	8,000	1839.......	17,500	1848... ..	25,000	1857.....	15,800	1866.....	16,100
1831........	7,500	1840.......	17,000	1849.......	23,500	1858.....	15,300	1867.....	15,200
1832........	10,000	1841......	20,500	1850.......	22,000	1859.....	16,400	1868.....	16,400
1833........	11,000	1842.......	24,000	1851.... ..	18,500	1860.....	15,600	1869.....	17,500
1834........	12,000	1843.......	25,000	1852.......	15.700	1861.....	14,100	1870.....	17,830
1835........	13,000	1844.......	26,000	1853.......	16,800	1862.....	14,200	1871.....	20,000
1836........	15,000	1845.......	30,000	1854.......	16,500	1863.....	14,800	1872. . ..	25,880
1837........	13,500	1846	28,000	1855... ...	15,800	1864.....	15,300		

PRODUCTION OF LEAD IN THE UNITED STATES.

Year.	Arizona and California.	Colorado.	Idaho, Montana.	Non-Argentiferous.*b*	Nevada.	Utah.	Other States.*a*	Mexico.*c*	Total Domestic.*d*	Grand Total.
1873....	....	56	....	22,381	....	15,000	5,103	....	....	42,540
1874....	....	312	....	*e*23,000	....	20,000	8,768	....	....	52,080
1875....	....	818	....	24,730	....	19,000	14,992	....	....	59,540
1876....	....	667	....	26,421	....	25,000	11,982	....	....	64,070
1877....	....	897	....	31,152	19,724	27,000	3,127	....	....	81,900
1878 ..	....	6,669	....	26,770	31,063	21,000	5,858	....	....	91,360
1879....	....	23,674	....	28,130	22,805	14,000	4,171	....	....	92,780
1880....	....	35,674	....	27,690	16,659	15,000	2,802	....	....	97,825
1881....	....	40,547	....	30,770	12,826	24,000	8,942	....	....	117,085
1882...	....	55,000	....	29,015	8,590	30,000	10,285	....	....	132,890
1883....	3,200	70,557	11,000	21,800	6,000	29,000	2,600	....	....	143,957
1884....	4,300	63,165	14,500	19,932	4,000	28,000	6,000	....	....	139,897
1885....	4,000	55,000	*e*15,000	21,975	3,500	23,000	6,937	....	....	129,412
1886....	*e*3,500	59,000	*e*22,000	20,800	3,400	*e*21,000	5,929	....	....	135,629
1887 ...	*e*3.500	63,000	27,000	25,148	3,400	*e*19,000	4,164	15,488	145,212	160,700
1888....	*e*3,500	*e*65,500	*e*30,000	29,090	2,400	*e*18,000	3,429	28.636	151,919	180,555
1889*f*...	3,200	69,000	32,500	29,258	1,950	16,500	4,989	25,570	157,397	182,967
1890 ...	1,500	54,500	33,000	31,351	2,000	18,000	3.525	18,124	143,876	161,754
1891 ..	2,000	64.000	40,000	34,000	2.500	28,000	7,633	*g*23,867	178,133	202,000
1892....	2,000	61,500	36,500	37,000	2,500	30,000	9.392	*h*39,608	178,892	218,500

* From *Mineral Resources of the United States*, 1889 and 1890.

(*a*) Includes New Mexico, from which State most of the metal credited in this column is derived. Small amounts came from Washington and South Dakota. (*b*) Nearly all the non-argentiferous lead produced in the United States is mined in Missouri, Kansas, Wisconsin, and Illinois. The statistics in this column, up to 1883, represent the output of these four States solely. In 1883 Virginia produced 200 tons and a small amount annually since that year; a portion of the output of these Eastern States in 1891 and 1892 was marketed as "desilverized," some of it, both in bullion and ores, having been used by the smelters of western "dry" ores. (*c*) The importation of Mexican lead began to assume important proportions in 1886, but no records of the amount brought into the United States in ores were kept prior to 1887. The figures in this column also include a small quantity of lead imported in ores from Canada, but the amount is trifling. (*d*) Small quantities of lead were brought into the United States in ores previous to 1887, though no records were kept of the amount. The figures in the column "Grand Total" for the years 1873–86, both inclusive, represent, practically, the domestic production. (*e*) Estimated. (*f*) The distribution of output among the various States for 1889 is an approximate one, based upon the figures of the Eleventh Census. (*g*) Includes 2700 tons of lead imported in base bullion and 21,162 tons imported in ores. (*h*) Includes 12,874 tons of base bullion brought into the United States, refined in bond, and exported, and 26,738 tons of lead imported in ores.

IMPORTS OF LEAD FOR CONSUMPTION IN THE UNITED STATES.

[Calendar years ending December 31 from 1886 to 1890; previous years end June 30.]

Year.	Ore and Dross.		Pigs and Bars.		Sheets, Pipe, and Shot.		Old and Scrap.		Manufactures. *n. e. s.*, Value.	Total Value.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.		
1867. ..	611	$25	65,322,923	$2,812,668	185,825	$9,560	1,255,233	$53,202	$6,222	$2.828,475
1868.....	6,945	239	63,254,677	2,668,915	142,137	7,229	2,465,575	101,586	6,604	2.682,987
1869.....	....	....	87,865,471	3,653,481	307,424	15,531	2,983,272	123.068	18,885	3.687,897
1870....	5,973	176	85,895,724	3,530,837	141,681	6,879	3,756,785	150,379	10,444	3,548.336
1871.....	316	10	91,496,715	3,721,096	86,712	4,209	2,289,688	94,467	8,730	3.734,045
1872. ...	32,331	1,425	73,086,657	2,929,623	15,518	859	4,257,778	171.324	20.191	2,952,098
1873. ..	....	....	72,423,641	3,233,011	525	62	3,545,098	151,756	21,503	3,254.576
1874.....	....	....	46,205,154	2,231,817	30,219	1,349	395,516	13,897	36.484	2,269,650
1875.....	13,206	320	32,770,712	1,559,017	58	4	382,150	13,964	25,774	1,585,115
1876.....	....	....	14,329,366	682,132	20,007	1,204	265,860	9,534	27,106	710.442
1877.....	1,000	20	14,583,845	671,482	16,502	1,242	249,645	8,383	1,041	673,785
1878.....	....	....	6,717,052	294,233	15,829	963	106,342	3,756	113	295,309
1879.....	....	....	1,216,500	42,983	3,748	209	42,283	1,153	930	44,122
1880.....	....	....	6,723,706	246,015	1,120	54	213,063	5,262	20,976	*268,198
1881.....	5,981	97	4,322,068	159,129	900	65	123,018	2,729	111,890	276.443
1882.....	21,698	500	6,079,304	202,603	1,469	99	220,702	5,949	62,139	268,070
1883.....	600	17	4.037,867	130,108	1,510	79	1,094,133	31,724	86,703	222,856
1884.....	419	13	3,072,738	85,395	15,040	630	160,356	4,830	127,949	245.711
1885.....	4,218	57	5,862,474	143,103	971,951	22,217	4,866	106	466,755	636,962
1886.....	715,588	9,699	17,582,298	491,310	27,357	1,218	24,726	882	559,284	1,061,617
1887.....	153,731	21,487	7,716,783	219,770	27,941	1,286	136,625	4,323	364,740	†608,165
1888.....	88.870	2,468	2,582,236	69,891	23,103	1,202	33,100	904	407,839	585,723
1889.....	328,315	7,468	2,773.622	76,243	35,859	1,417	50,816	1,494	425,144	511,176
1890.....	493,463	12,947	19.336,233	593,671	68,314	3,338	*a*	*a*	1,210.387	1.821,837
1891.....	105,898	6,721	3,392,562	104,184	334,179	12,406	....	....	2,744,122	2,867,633
1892.	....	....	....	....	....	....	....	....	....	4,570.238

n. e. s. = not elsewhere specified. (*a*) Included in Pigs and Bars after 1889.

* The total value of imports from 1880 on is taken from the Summary Statement of the Imports and Exports of the United States Bureau of Statistics.

† In the years from 1887 on is included ores from Mexico, which amounted in 1887 to 15,488 short tons; 1888 to 28,636 tons; 1889 to 25,570 tons; 1890 to 18,124 tons; 1891 to 23,867 tons; and 1892 to 39,608 tons.

EXPORTS OF LEAD AND MANUFACTURES OF LEAD, OF DOMESTIC PRODUCTION.

Year.*	Manufactures of Lead. Pounds.	Manufactures of Lead. Value.	Pewter and Lead. Value.	Bars, Shot, etc. Pounds	Bars, Shot, etc. Value.	Total Value.
1790	13,440	$810	....	....	....	$810
1803	900	....	....	....	....	....
1804	19,804	....	....	....	....	....
1805	8,000	....	....	....	....	....
1808	40,583	....	....	....	....	....
1809	126,537	....	....	....	....	....
1810	172,323	....	....	....	....	....
1811	65,497	....	....	....	....	....
1812	74,875	....	....	....	....	....
1813	276,940	....	....	....	....	....
1814	43,600	....	....	....	....	....
1815	40,245	....	....	....	....	....
1816	35,844	....	....	....	....	....
1817	111,034	9,993	....	....	....	9,993
1818	281,168	22,493	....	....	....	22,493
1819	94,362	7,549	....	....	....	7,549
1820	25,699	1,799	....	....	....	1,799
1821	56,192	3,512	....	....	....	3,512
1822	66.316	4,244	....	....	....	4,244
1823	51,549	3,098	....	....	....	3,098
1824	18,604	1,356	....	....	....	1,356
1825	189,930	12,697	....	....	....	12,697
1826	47,337	3,347	$1,820	....	....	5.167
1827	50,160	3,761	6,183	....	....	9,944
1828	76,882	4,184	5,545	....	....	9,729
1829	179,952	8,417	5,185	....	....	13,602
1830	128,417	4,831	4,172	....	....	9,003
1831	152,578	7,068	6,422	....	....	13,490
1832	72,439	4,483	983	....	....	5,466
1833	119,407	5,685	2,010	....	....	7,695
1834	13.480	805	2,224	....	....	3,029
1835	50.418	2,741	433	....	....	3,174
1836	34,600	2,218	4,777	....	....	6,995
1837	297,488	17,015	3,132	....	....	20,147
1838	375.231	21,747	6,461	....	....	28,208
1839	81,377	6,003	12,637	....	....	18.640
1840	882,620	39,687	15,296	....	....	54.983
1841	2,177,164	96,748	20,546	....	....	117,294
1842	14,552,357	523,428	16,789	....	....	540,217
1843	15,366,918	492,765	7,121	....	....	499,886
1844	18,420,407	595,238	10,018	....	....	605,256
1845	10,188.024	342,646	14,404	....	....	357,050
1846	16,823,766	614,518	10,278	....	....	624,796
1847	3,326,028	124,981	13,694	....	....	138,675
1848	1,994,704	84,278	7,739	....	....	92,017
1849	680,249	$30,198	$13,196	....	....	$43,394
1850	261,123	12,797	22,682	....	....	35,479
1851	....	....	16,426	229,448	$11,774	28,200
1852	....	....	18,469	747,930	32,725	51,194
1853	....	....	14,064	100,778	5,540	19,604
1854	....	....	16,478	404,247	26,874	43,352
1855	....	....	5,233	165,533	14,298	19,531
1856	....	....	5.628	310,029	27,512	33,140
1857	....	....	4,818	870,544	58,624	63,442
1858	....	....	27,327	900,607	48,119	75,446
1859	....	....	28,782	313,988	28,575	57,357
1860	....	....	56.081	903,468	50,446	106.527
1861	....	....	30,534	109,023	6,241	36,775
1862	....	....	28.832	79,231	7,334	36,166
1863	....	....	30,609	237,239	22,634	53,243
1864	....	....	30.411	223,752	18,718	49,129
1865	....	....	29,271	852,895	132,666	161,937
1866	....	....	44,483	25,278	2,323	46,806
1867	....	....	27,559	99,158	5,300	32,859
1868	....	....	37,111	438,040	34,218	71,329
1869	....	....	17,249	....	....	17,249
1870	....	28.315	....	....	....	28,315
1871	....	79,880	....	....	....	79,880
1872	....	48,132	....	....	....	48,132
1873	....	13,393	....	....	....	13,393
1874	....	302,044	....	....	....	302.044
1875	....	429,309	....	....	....	429,309
1876	....	102,726	....	....	....	102,726
1877	....	49,835	....	....	....	49.835
1878	....	314,904	....	....	....	314,904
1879	....	280,771	....	....	....	280,771
1880	....	49,899	....	....	....	49.899
1881	....	39,710	....	....	....	39,710
1882	....	178,779	....	....	....	178,779
1883	....	43,108	....	....	....	43,108
1884	....	135,156	....	....	....	135,156
1885	....	123,466	....	....	....	123,466
1886	....	136,666	....	....	....	136,666
1887	....	140,065	....	....	....	140,065
1888	....	194,216	....	....	....	194,216
1889	....	161,614	....	....	....	161,614
1890	....	181,030	....	....	....	181,030
1891	....	173,887	....	....	....	173,8[illegible]7
1892	....	154,375	....	....	....	154,375

* Fiscal years ending Sept. 30 from 1790 to 1843 (1843 is for 9 months); from 1844 to 1886 ending June 30 (1886 is for 18 months); calendar years from 1887 forward.

PIG LEAD PRODUCTION OF THE PRINCIPAL COUNTRIES OF THE WORLD.

(In Metric Tons of 2204 lbs.)

	United States.	United Kingdom.	Germany.	Italy.	Austria.	Hungary.	Russia.	Sweden.	Spain.	Canada	New South Wales.
1885	117,434	38,399	93,134	16,461	8,525	*2,100	714	....	78.986	....	194
1886	123,075	40,122	92,520	19,508	8,048	2,105	776	....	94,895	....	....
1887	145.827	38,411	94,921	17,795	7,826	1,779	988	282	119,932	‡93	....
1888	163,643	38.190	96,995	17,481	7,993	1,995	798	328	161,462	306	18,382
1889	166.031	36,189	100,601	18.165	8,218	2,385	578	254	*162,000	75	35,146‡
1890	146,780	34,139	101,781	17,768	8,297	1.255	838	310	163,838	51	41,996
1891	183,303	32.731	95.615	18.500	7.583	*1.100	*900	299	†235.000	267	56,304

Official figures except when the contrary is stated.

* Estimated. † U. S. Consular report. ‡ First reported.

From New South Wales there were exported of lead ore, tons in 1885, 2,128; 1886, 4,880; 1887, 12,734; 1888, 11,915; 1889, 47,735; 1890, 91,189; 1891, 93,897. The *production of lead* in New South Wales is so intimately connected with the silver-lead returns as not to be capable of separate statement. All the figures relating to N. S. W. are returns of exports, and not of actual production.

It should be remembered that the distribution of the product in the table according to States (p. 310) is approximate only; still, we believe that it is very nearly correct. The returns which we received for 1892 from the smelters and refiners enabled us to trace the bullion product for that year from the refiners to the producers of base bullion, and from the latter to the States in which the ore originated. The statistics for the years 1873–91 have been revised from those published in the statistical number of the *Engineering and Mining Journal*, Jan. 2, 1892, and have undergone some alterations. This explanation will, therefore, account for any discrepancies which may be observed in comparing the two.

The average market prices of lead in New York for each month since January, 1870, are given herewith:

AVERAGE MONTHLY PRICES OF LEAD IN NEW YORK, IN CENTS PER POUND.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1870..	6.25	6.21	6.15	6.20	6.22	6.22	6.25	6.35	6.33	6.31	6.30	6.30	6.25
1871..	6.22	6.22	6.17	6.15	6.14	6.13	6.12	6.06	6.05	5.93	5.95	5.87	6.08
1872..	5.95	5.93	5.93	6.00	6.43	6.50	6.50	6.45	6.40	6.51	6.55	6.51	6.30
1873..	6.32	6.45	6.37	6.37	6.50	6.33	6.06	6.12	6.50	6.50	6.25	6.06	6.32
1874..	5.95	6.12	6.18	6.07	5.87	5.81	5.71	5.72	5.87	6.22	6.37	6.26	6.01
1875..	6.10	5.87	5.68	5.83	5.92	5.82	5.97	5.91	5.78	5.62	5.76	5.90	5.85
1876..	5.93	6.17	6.45	6.26	6.30	6.37	6.27	6.32	6.12	5.90	5.75	5.67	6.13
1877..	6.12	6.30	6.62	6.37	5.77	5.65	5.50	5.00	4.80	4.55	4.62	4.55	5.49
1878..	4.17	3.75	3.75	3.62	3.37	3.30	3.43	3.35	3.35	3.48	3.77	3.95	3.61
1879..	4.25	4.50	3.87	3.06	3.00	3.46	4.00	4.02	3.87	4.75	5.30	5.55	4.14
1880..	5.80	5.93	5.62	5.57	4.82	4.62	4.50	4.65	4.85	4 76	4.80	4.50	5.04
1881..	4.65	4.95	4.75	4.60	4.47	4.37	4.70	4.85	5.16	5 06	5.07	5.12	4.81
1882..	5.05	5.10	5.00	4.95	4.72	4.72	5.02	5.02	5.05	5.00	4.70	4.62	4.91
1883..	4.65	4.55	4.57	4.50	4.47	4.42	4.35	4.25	4.31	4.22	3.85	3.67	4.32
1884..	4.12	3.90	4.12	3.84	3.63	3.61	3.62	3.61	3.65	3.67	3.46	3.62	3.74
1885..	3.65	3.65	3.65	3.65	3.65	3.75	4.00	4.25	4.25	4.20	4.10	4.55	3.95
1886..	4.55	4.75	4.90	4.78	4.70	4.75	4.87	4.75	4.65	4.22	4.35	4.32	4.63
1887..	4.31	4.37	4.32	4.27	4.52	4.65	4.55	4.58	4.50	4.25	4.40	5.12	4.50
1888..	4.90	4.95	5.15	4.75	4.25	3.90	3.97	4.45	5.00	4.50	3.67	3.75	4.42
1889..	4.84	3.73	3.72	3.68	3.78	3.96	3.88	3.86	4.00	3.86	3.84	3.89	3.93
1890	3.86	3.85	3.95	4.05	4.20	4.42	4.62	4.60	5.11	5.87	5.02	4.24	4.48
1891..	4.38	4.31	4.35	4.25	4.28	4.48	4.42	4.42	4.52	4.39	4.12	4.25	4.35
1892	4.20	4.12	4.21	4.15	4.22	4.16	4.13	4.11	4.11	4.02	3.84	3.80	4.09

Statistics of Lead in the United Kingdom.

The following statistics of lead in the United Kingdom are taken from the annual metal circular issued by Messrs. W. T. Sargant & Son, except the production of lead in 1883 to 1890, inclusive, which is from the official Government Statistical Tables.

	1892, Tons.	1891, Tons.	1890, Tons.	1889, Tons.	1888, Tons.
Production of British mines ..	30,000*	32,000*	33,590	35,604	37,578
Imports..........................	182,782	169,724	158,649	145,451	132,911
Exports..........................	58,101	48,726	55,536	52,153	48,653
Highest price of soft pig......	£11 5s. 0d.	£12 12s. 6d.	£14 15s.	£14 15s.	£15 15s.
Lowest " " " "	9 17s. 6d.	11 5s.	12 5s.	12 5s.	12 5s.

	1887, Tons.	1886, Tons.	1885, Tons.	1884, Tons.	1883, Tons.
Production of British mines..	37,890	39,482	37,687	40,075	43,419
Imports..........................	114,382	107,878	108,063	109,014	101,589
Exports..........................	44,367	42,388	38,578	33,539	39,267
Highest price of soft pig......	£15 15s.	£13 12s. 6d.	£12 10s.	£11 10s.	£13 10s.
Lowest " " " "	1[illegible] 7s. 6d.	12	10 5s.	10 2s. 6d.	11 10s.

* Estimated.

The New York Lead Market in 1892.

The limits of consumption have again expanded, and the deliveries of the year will be larger than last, not only for pipes, sheets, etc., but also for white lead. Consequently the production has increased correspondingly, and this in the face of the prolonged strikes and total cessation of work in the Idaho district. Smelters west of the Mississippi were also much injured by reason of the cutting off of what had hitherto been regular supplies, and were scantily stocked for the first six or eight months of the year. But, with the energy characteristic of our mining industry and the people engaged in it, they resorted to other quarters, which were either new, by reason of not having been worked for some time, or which had not been worked up to their fullest capacity. In this way their difficulties were overcome, and, contrary to the expectations of most, the withdrawal of raw material from the important Idaho district had little effect on the output of refined metal.

Later, when the Idaho strikes approached a termination, it quickly became apparent that the production of lead would materially increase, and though consumption was going on at a very good rate, there was a heavy decline in prices, which had been rather low throughout the year.

The outside range of values was 4.30@3.80c per lb., the former being the figure ruling at the beginning of the year and until the close of January; in February $4\frac{1}{8}$c. was reached; then came a quick advance to $4\frac{1}{4}$c., shortly followed by a reaction, which in turn was succeeded by an upward movement, advancing prices to $4.27\frac{1}{2}$@4.30c., this point being reached near the end of May. Here the upward movement ended, and June found sellers at 4.10c. Although prices advanced to 4.20c. in July and August, the tendency was rather flat, and by the end of September 4.05c. became the ruling price. After that the market made rapid strides downward, first to 4c., and then in the beginning of November to 3.95c., sales soon afterward being made at 3.90c. $3\frac{3}{4}$c. was practically the lowest price of the year, although the bulletin quotation was for a while established at 3.70c., and ruled pretty well from November up to the middle of December, when all of a sudden, without any good reason except a slight improvement in the demand, the price was jumped up, reaching 3.85@3.875c., which were practically the closing values, although the tendency was again weaker, the production continuing at the same heavy rate as before, even though the price of silver was continually dropping, and ought to reduce the output of lead.

The London market closed at £9 17s. 6d. for Spanish lead, and at £10 for English.

There are no large reserved stocks of refined lead; hardly anything is in store at New York, Chicago, or St. Louis, at which latter places the holdings were very considerable a few years ago. At the smelting-works the same state of affairs exists, nearly the entire production being shipped from day to day as it is ready for market. In view of this, any emergency arising would have an appreciable effect on values, but evidently the probability of this is not considered great enough to warrant attention being given to it. In the meantime the continual decline and the low prices have left this article with few friends.

In connection with all predictions of prices, two important factors must be

considered—the National Lead Company, controlling the white-lead business, and the Lead Shot combination, the two heaviest consumers of the country, and which have the greatest possible interest in keeping down the prices of the raw material they must buy while they keep up the values of the commodities they have to sell. Having concentrated more and more the matter of buying, and being able to help out one mill that may be short by diverting something from the stock of another, they are able to buy at such times as best suit them, and to force the smelters and refiners to come to them, whereas in former years the cases were practically reversed.

However low the prices here may appear, if we compare them with the 2c. per lb. ruling in Europe they still seem rather high; there, however, large quantities of lead, produced as the by-products of the more precious metals, are sold for what they will bring. It must be considered also that here, though freights are low, the refined metal must be brought by rail, or by rail and water, a distance often of 2000 miles.

It is argued that the new Democratic administration, soon to come into power, will among its first acts put lead and silver ores on the free list. We do not think there will be any alteration of the laws much before 1894. Even then only limited quantities, for which almost fancy prices must be paid, can be had from Mexico, as, thanks to the narrow-minded policy that has been pursued in this country for the last four years, the smelting industry in Mexico has now become firmly established, to the detriment of our Western miners and smelters and railroads, the former missing these valuable fluxing ores, and the latter the money earned by hauling them from Mexico to the smelting works. The returns from the Mexican works show that our last year's estimate that their output would amount to nearly 3000 tons monthly during 1892 was very close to the facts. Judging from reports recently received, there will be a still further increase in 1893, and during the first six months thereof we believe the monthly production will amount to about 4000 tons, or, say, 45,000 tons of lead per annum, equaling one fifth of the United States production. We are glad to be able to record that this Mexican smelting industry is almost entirely in the hands and under the control of Americans, and that at present American fuel is used almost exclusively. Even this is but slight recompense for the withdrawal of the business from this country.

The low prices of silver established during the year have not yet had any effect on the production of silver-bearing lead ores, nor do we expect that they will have unless they decline much more; yet the large silver output of Mexico, from the new smelting industry which our policy has established there, will, of course, help to depress the price of that metal. There is a kind of poetic justice in this, for our Western silver-miners, deceived by certain special interests, were the most urgent advocates of excluding Mexican lead ores from this country. Their reward has been an increase here of smelting charges on dry silver ores to the average extent of $2.50 a ton, and the lower price of silver, partly through the increased Mexican output—results that, at the time, the *Engineering and Mining Journal* frankly told would come to pass.

The London Lead Market in 1892.

Soft foreign lead opened at £11 5s., and consumptive demand being weak, whilst sales were pressed, prices made steady progress downward all through January, £10 7s. 6d. being taken at the end of the month. A momentary rally to £10 17s. 6d. was followed by a relapse to £10 10s. by the middle of February.

A better demand experienced during the second fortnight of February revealed an unexpected scarcity of supplies, and values at once improved to the extent of five shillings, £10 7s. 6d. being paid for Spanish, whilst for English £11 was obtainable and £11 5s. demanded. March witnessed no essential change in price. The export trade in Spanish lead to France was complained of, but there was a good demand for English lead from that country. On the other hand, there were large arrivals from Spain and Australia. At one time, £10 18s. 9d. was paid, but the price at the close of the month was £10 15s. April was a month of plentiful supply but poor demand, and consequently a month of drooping values, £10 7s. 6d. being ultimately reached. The close was about 2s. 6d. better. May, after a spell of dullness, finished up firmer with plenty of buyers and not much lead to be had. For soft foreign £10 16s. 3d. was paid at the close and £10 17s. 6d. on June 1. English makers were well sold and asking a higher price, viz.: £11 2s. 6d. June destroyed the improvement recorded in May, and at the end of the month there were no buyers of soft foreign above £10 6s. 3d. The strike at the Broken Hill mines in Australia had scarcely any effect on our market in July, shipments continuing to be made from the supplies which had accumulated at the shipping ports in Australia. Values varied only from £10 10s. to £10 7s. 6d. Throughout August prices steadily declined, £10 2s. 6d. being finally accepted for soft foreign. During the first half of September, smelters complained a good deal of the state of trade—consumers buying only what they absolutely required, and lead went a begging at £10 2s. 6d. At this point came a turn in the long lane of declining prices. Quarantine regulations in connection with the outbreak of cholera interrupted shipments from Spain, whilst from Australia the shipments in September, owing to the Broken Hill strike, were only 1600 tons as against a previous monthly average of about 4500 tons. The scarcity of prompt supplies thus caused, coupled with a good demand for spot, sent the value up to £10 10s. for foreign and £10 12s. 6d. English at the end of September. The improvement proved to be of only brief duration, an easier market ensuing on the removal of the said quarantine regulations and the consequent expectation of freer shipments from Spain. October, accordingly, closed flat at £10 5s. foreign and £10 10s. English.

It is of interest to note that English consumers have been supplied largely during the last few months with American soft pig-lead, large and regular quantities of which are now coming to this country.

A decline to £10 1s. 3d. for soft foreign early in November resulted in considerable sales, and we close firmer on Nov. 15 at £10 2s. 6d. to £10 5s. at £10 7s. 6d. to £10 10s. English soft foreign.

The Treatment of Zinc-Lead Sulphides.

By Stephen H. Emmens.

Among the most important problems of the mineral industry of to-day is the question of how to profitably utilize the enormous quantities (amounting to millions of tons) of mixed blende and galena that have been opened in Colorado, New South Wales, and other mining countries. These ores contain notable proportions of silver (and, frequently, gold), but are unmarketable owing to their zinc contents, which occasion great loss and inconvenience in ordinary smelting operations. If, in a blast-furnace, it be attempted to flux off the zinc, that metal, being volatile at a high temperature, rises to the throat of the stack and is there oxidized, forming hard, infusible lumps and compelling frequent stoppages; while the great heat necessitated in the lower part of the furnace involves a considerable loss of lead and silver by volatilization. On the other hand, if the mixed ore be smelted for zinc, the associated lead forms a fusible compound with the silicious materials of the retorts and precludes any successful results.

The following is a brief statement of the attempts hitherto made to solve the problem:

1. *Mechanical Separation.*—The specific gravity of blende is 4 and that of galena is 7.5. Hence, if it were possible so to crush the mixed ore as to break the two sulphides apart from each other, they could be separated by jigging. This is successfully accomplished in cases where the ores are very coarse-grained; but all attempts to similarly separate the blende from the galena in fine-grained mineral have failed. Moreover, as both the blende and the galena in fine-grained ores are argentiferous, the separation, if successful, would still be attended by a great loss of silver. Mechanical separation is, therefore, out of the question.

2. *Modified smelting.*—The most prominent method under this head is the well-known Bartlett process, which consists in smelting the ores for the express purpose of volatilizing the zinc, and providing special chambers and apparatus for collecting the lead sulphate and zinc oxide that pass away from the furnace, while the residual slag and matte contain the iron together with some of the lead and silver, and are suited for admixture with ordinary smelting charges. It is claimed that the condensed fumes are marketable as a pigment, and that the loss of silver is not more than 15%. As, however, the American Zinc-Lead Company's works on this system commenced operations in the spring of 1891 and treated 100 tons daily of the blende tailings from the dressing floors at Leadville, it seems probable that the practical success of the method, if attained, would, ere now, have been widely published. The *a priori* objections to the method are twofold; first, the treatment of ores rich in blende and low in galena can hardly be effected with less than three fire operations, namely, a preliminary roast, a crude-fume smelting, and a refining smelting, in addition to the ignition of the crude fumes and the double work of collection, all of which entails a relatively heavy cost; and, secondly, no continuous market for any very large quantity of pigment is possible.

Another smelting method is to melt the ores with alkalies or alkaline carbonates, whereby lead and the silver from the galena separate out in a metallic state and the blende remains in the slag, from which it can be afterwards separated by

decomposing the slag with water. This process was tested at the Broken Hill Proprietary mine, in New South Wales, without success.

3. *Removal of the Zinc by Chemical Methods.*—If blende be roasted with access of air, the zinc is converted partly into sulphate and partly into oxide. The former of these substances is removable by lixiviation with water, and the latter is separable by leaching with dilute acid. Hence, a roast followed by two lixiviations, or even by one, if dilute acid be employed at the outset, affords a method of freeing the ore from zinc. This general principle of operation (introduced by Grimm, in Bohemia, in 1846) is the common basis of the following chemical processes for the treatment of zinc-lead sulphides:

a. The Parnell process, which involves the following operations: (1) Roast at a low heat. (2) Leach with water. (3) Heat with sulphuric acid in revolving lead-lined pans. (4) Leach with water; add to the liquor from 2, and precipitate any contained copper by means of scrap iron. (5) Evaporate the solution down to a moist paste, with which incorporate one-fifth of its (dry) weight of finely-powdered blende. Dry and calcine in a muffle; the effect being that the sulphur and sulphuric anhydride unite and escape as SO_2, while the zinc remains behind as oxide and is then smelted. (6) The leached ore is calcined and then forms an iron-lead silver concentrate suited for use as an ordinary smelting material. This process was operated successfully from 1879 to 1883 at Llansamlet, Swansea, in South Wales. It is understood that the losses of lead and silver did not exceed 4% of the assay values, and that about 80% of the zinc was obtained in a metallic form. The SO_2 from the blende-roaster and the sulphate-calciner was conducted to a vitriol chamber and there converted into the sulphuric acid required for leaching.

b. The West Process.—(1) Roast; cool; moisten with water; and place upon a layer of pebbles in a false-bottomed tank. (2) Draw the SO_2 from the roasting furnace and force it through the ore in the tank together with a jet of steam. The effect of this is to convert the zinc oxide into sulphite which, in its turn, changes to sulphate. (3) Remove the ore to a separate vat and leach with water. Then precipitate the zinc as hydrate by passing a steam of gaseous ammonia into the liquid, which, when freed from zinc, is a solution of ammonium sulphate and is transferred to a still where, by being heated with lime, it reproduces the NH_3. (4) The leached ore containing the lead, iron, and precious metals is dried on an iron floor heated by the gases from the roasting furnace, and then constitutes a free-smelting concentrate. This process was tried during 1889 and 1890 at Thomasville, N. C., where some hundreds of tons of zinc-lead sulphides from the Silver Valley mine were treated with the result of saving 80% of the lead, 70% of the zinc (as oxide), and practically the whole of the precious metals.

c. The Maxwell-Lyte process consists in dissolving the calcined ore in hydrochloric acid, precipitating the dissolved lead by metallic zinc and then precipitating the contained zinc by lime. It does not appear to have been practically adopted.

d. The Alkaline Process.—Inasmuch as zinc oxide is soluble in alkaline solutions, attempts have been made to treat zinc-lead sulphides by (1) roasting, (2) leaching out the zinc sulphate with water, and (3) removing the residual zinc oxide with an alkaline solution instead of an acid. The only sufficiently cheap

alkali for this operation is lime ; but this substance has the disadvantage of forming a soluble compound with lead oxide, and thus fails to effect the desired separation.

e. Chlorination.—If partially roasted blende be mixed with common salt and re-roasted, much of the zinc is converted into chloride and may be removed by lixiviation with water. But the separation thus effected is only partial, as the lead and silver are also attacked by chlorine and find their way into the solution in appreciable quantities ; while a good deal of the zinc escapes from the furnace in the form of volatilized chloride.

4. *Removal of the Lead by Chemical Methods.*—This class is represented by the late Mr. Spence's treatment of the zinc-lead sulphide occurring as "bluestone" at the Parys Mountain mine in the Island of Anglesea. It consists in treating the crushed ore in a raw state with hydrochloric acid, which attacks the galena in preference to the blende. The lead chloride thus formed is leached out with hot water, and the metal precipitated therefrom by means of carbonate of lime, while the residual blende (accompanied by any precious metals present in the ore) is smelted for zinc.

5. *Electrolytic Separation of the Zinc.*—If a sulphide of a soluble metal be made the anode of an electrolytic bath in which the electrolyte contains an acid element, the metal will enter into solution and will pass over to the cathode, while the sulphur is left behind. Deligny, Luckow, and Blas & Miest have all availed themselves of this reaction for the treatment of blende. Luckow constructs his anode in the form of a cage filled with a mixture of coke and ore. Deligny makes use of a plate of carbon in contact with the pulverized ore. Blas & Miest agglomerate the crushed ore into plates by pressure and heat, and then use these plates as anodes. But in every case practical experience has shown that the attack on the anodes is very imperfect, and that the anodes themselves are too feebly conductive to admit of any satisfactory results being attained.

6. *Electrolysis and Chemical Action combined.*—Zinc may be obtained in a metallic form if its solution be subjected to electrolysis with an anode of carbon or other inert material. The solution thus freed from metal is capable of dissolving a fresh quantity of zinc oxide. Accordingly, by alternate leaching and electrolysis a limited quantity of acid may be employed to remove the zinc from an unlimited quantity of ore. The chief examples of this general method are the following :

a. The Létrange Process.—The ore is roasted and placed in leaching tanks, where it is subjected to the action of water together with the sulphurous anhydride generated in and drawn from the furnace. The solution of mixed sulphate and sulphite flows from the leaching tanks into a series of electrolytic baths, where it parts with its metal and becomes fully oxidized into free dilute sulphuric acid. This acid is transferred back to the leaching tanks for the treatment of a fresh charge of ore, and so on, until by the accumulation of impurities and the gradual neutralization of the acid by lime and other basic substances a fresh supply of liquid becomes necessary.

b. The Siemens & Halske Process.—This, like the Hoepfner process hereinafter described, has hitherto been practically applied only to the treatment of copper ores; but its inventors claim, with some reason, that it is equally suitable for the

treatment of blende. It is the simple operation of alternate electrolization and leaching already explained, but with an important practical modification, namely, that a solution of ferrous sulphate is added to the electrolyte. This substance is avid for oxygen and thus prevents polarization at the surfaces of the anodes; while the product of its oxidation is ferric oxide, which unites with a quantity of sulphuric acid 50% in excess of the corresponding ferrous oxide. The acid set free from the deposited metal is thus taken up by the ferric oxide and passes forward as ferric sulphate to the leaching tank, where it dissolves a further supply of metal, not only from the oxide present, but even from the sulphides. Hence in this process the ore may be treated in a raw state.

c. The Hoepfner Process.—This also has hitherto been applied only to the treatment of copper ores. It consists in alternate electrolization and leaching, but the electrolyte is cuprous chloride, which takes up the chlorine liberated at the anode (thereby preventing polarization and, indeed, generating an additional electromotive force) and forms cupric chloride. This latter passes from the bath to the leaching vat, where it attacks the raw sulphides, dissolving the metals and precipitating free sulphur. It may be doubted whether the process would prove successful if applied to zinc-lead sulphides.

d. The Kiliani Process.—In this case the electrolyte is ammonia-water holding ammonium carbonate in solution, and is of course applicable only to roasted blende.

e. The Lambotte-Doucet Process.—The ore is roasted and dissolved in hydrochloric acid. Chloride of lime is added to peroxidize the iron in the solution, and the ferric hydrate is then precipitated by the zinc oxide contained in a further quantity of the roasted ore. The metal is separated by electrolysis, and the electrolyte is used over again for attacking a fresh charge of ore. This process was tried at the Bleiberg mines, but did not prove successful.

f. The Watts Process.—This is a system of alternate electrolization and leaching, the blende being fully roasted, and the electrolyte being acetic acid or a solution of acetate of zinc. In the case of ores carrying lead in addition to zinc the process is clearly inapplicable.

From a consideration of the facts set forth in the foregoing summary it would appear that of all the processes described four only have any pretensions to be considered a solution of the zinc-lead sulphide problem; namely, those of Parnell, West, Létrange, and Siemens & Halske. But each of these quasi-successful methods is subject to certain limitations and disadvantages.

The Parnell process involves the manufacture of sulphuric acid. It therefore requires a large capital expenditure and is quite unsuited for operation in most mining districts. The cost of treatment is usually estimated at about $6 per ton.

The West process requires at least two treatments of the roasted ore with sulphurous acid and steam for a total period of some 40 hours; and as the leaching with water must be effected in other than the sulphating vats, considerable transference backward and forward is necessitated. A blowing engine is also required for drawing the gases from the furnace and forcing them through the ore in the sulphating tanks; and the addition of an ammonia factory is a serious item. Altogether the cost of the process must be considerable, and the treatment of any large quantities of ore would require a plant of enormous dimensions and cost.

The method, moreover, cannot be depended upon to remove more than about two thirds of the zinc; and even for this it requires a very careful and complete roasting of the ore, as any unchanged sulphides are not attacked in the sulphating vats.

The Létrange and the Siemens-Halske methods both involve the establishment of an electrolytic plant, and the former also requires the provision of apparatus for collecting the furnace gases and forcing them through the roasted ore. Siemens & Halske's estimate for a plant capable of producing 1000 kilos, or $1\frac{1}{10}$ tons of copper per day of 24 hours is 209,600 marks, or, say, $40,000; and the cost of working is estimated by them at .23865 marks per kilo of copper produced, or, say, 2 cents per pound. In the case of zinc the cost of the plant may be taken at about the same, but the cost of working must be considerably higher, and is not likely to amount to less than 3 cents per pound, a fairly favorable figure if comparison be made with the selling value of the zinc produced. But when we consider that zinc-lead sulphides generally carry upwards of 20% of zinc, it will be evident that Messrs. Siemens & Halske's $40,000 plant (which would cost twice or thrice that amount in most mining districts) would only be capable of treating some 5 or 6 tons of ore daily—a practical *reductio ad absurdum.*

In conclusion, it may be pointed out that the conditions of any true solution of the problem are as follows: (*a*) The method of treatment must be applicable at the mine. (*b*) It must not involve any complicated apparatus or skilled labor. (*c*) It must be relatively rapid and capable of operation on the largest scale. (*d*) It must dispense with the employment of acids or any reagents that have to be brought from a distance. (*e*) It must remove the zinc and leave the lead and silver. (*f*) The cost of treatment must be well below the market value of the products.

There is reason to believe that the coming year will show these conditions to be by no means impossible of fulfilment.

Recent Progress in the Treatment of Argentiferous Lead Ores.

By H. O. Hofman, M.E.

The following paper on the progress made in this country of late years in the treatment of argentiferous lead ores will consist of four parts: (1) a general review of smelting silver-lead ores in the blast-furnace; (2) a general review of the desilverization of base bullion; (3) the recent improvements in smelting; (4) the recent improvements in desilverizing.

In the United States the blast-furnace has been almost exclusively used from the very first, as silver-lead ores suited for the reverberatory furnace are of too rare occurrence to warrant separate treatment. According to Mr. O. H. Hahn,* the first successful works were erected about the year 1867 in Montana and Nevada. In the Argenta† mining district, then the most prominent one in Montana, galena ores were roasted in heaps and in reverberatory furnaces and then smelted with charcoal in small blast-furnaces, a furnace treating from two to five tons of ore per day. The base bullion, worth from $200 to $750 in silver per ton, was cupelled, and only the silver bullion shipped, as the cost of transporting the lead to its Eastern market was too high. The furnace in common use was the German cupelling furnace, holding about five tons of base bullion. Ores having a value of less than $100 in silver per ton could not be treated at a profit.

Similar conditions prevailed at first at Oreana,‡ Nev. Here the ores, containing 50 per cent. lead and $80 worth of silver per ton, were mixed with soda and lime and smelted with charcoal in a small blast-furnace at the rate of twelve tons per day. At first the base bullion was cupelled in an English cupelling furnace, the cost of smelting and cupelling being about $50 per ton of ore, but later it was shipped by the Central Pacific Railroad to San Francisco, to be refined there. The following is a statement of the costs of mining, smelting, and shipping in 1868 with the value of the metals in San Francisco:

Mining Cost.—Twelve tons of ore daily, mined and hauled to mill, $84.

Reduction Cost, Twelve Tons Daily.—Four smelters, two at $5.00 and two at $2.50, $15; two engineers, at $4, $8; five laborers, feeders, etc., at $3.00, $15; two cords of wood, at $15.00, $30; limestone, iron, horse-feed, etc., $10; charcoal, 144 bushels, at 25 cents, $36;—total daily labor and material, $198; add for superintendence, office, etc., $25; transportation 4.8 tons metal to San Francisco, $144; total cost of metal from 12 tons of ore, $367.

Value of Metal in San Francisco.—Four and eight-tenths tons lead and antimony, at $100, $480; three hundred and sixty ounces silver (the average contents), at $1, $360; total, $840. Subtract cost of production, etc., $367, leaving $473 profit.

From this it will be seen that in Nevada, as in Montana, only ores running high in silver could be worked at a profit, although the value of the lead made some difference in favor of Nevada, on account of the nearer market for it. No figures are given above of the loss in metal, but accepting the 50 per cent. pre-

* Mineral Resources of the United States, 1882, p. 324.

† Mining Commissioner's Reports, 1868, p. 54; 1869, p. 150; 1870, p. 310; 1872, p. 267; and following vols.

‡ Mining Commissioner's Reports, 1868, p. 331; 1869, p. 131.

viously mentioned as the average lead contents of the ore, the loss must have been about 20 per cent. Higher losses are recorded in the Eureka* district, where the smelting industry began a little later. The ores, which were carbonate and basic, contained, as prepared for the blast-furnace, from 40 per cent. to 48 per cent. lead, $60 to $80 worth of silver and from $15 to $20 worth of gold to the ton, and were rich in arsenic. The furnaces in which the ores were smelted were 2 ft. square at the tuyères; 1½ ft. higher up their size was increased, by a bosh, to 3 ft.; the shaft, extending from 12 ft. to 16 ft. above the tuyères, was considerably contracted at a few feet below the feed-floor. The bottom of the crucible, partly external and partly internal, was 2 ft. below the level of the tuyères. There were three water-cooled tuyères having 3-in. nozzles. The ore was charged with 28 per cent. of slag into the furnace; the weight of the fuel (charcoal) was 56 per cent. of the ore or 44 per cent. of the charge. The slag formed—SiO_2 30.20 per cent., FeO 50.60 per cent., Al_2O_3 3.01 per cent., CaO 7.10 per cent., MgO 0.90 per cent., PbO 8.70 per cent.—was pretty rich in iron and lead. The furnace smelted from eight to nine tons of ore in twenty-four hours, and the cost of smelting was $20 a ton; the base bullion, worth $250 in silver and gold to the ton, was shipped to Newark, N. J., to be desilverized. With a furnace of such a construction, with such a percentage of fuel and such an amount of blast, it is not to be wondered at that losses as high as 40 per cent. in lead and 30 per cent. in silver were not uncommon.

In Utah† silver-lead ores were mined and shipped before 1870, but the first blast-furnace run was built in that year at Salt Lake City, which soon became, and has remained ever since, the smelting centre west of the Rocky Mountains.

The foregoing examples will suffice to give the general character of the early silver-lead smelting. They show that, judging by present standards, the work done was very imperfect. This was caused in part by the unfavorable conditions under which it had to be carried out, such as the use of inferior charcoal as the exclusive fuel, and the lack of good refractory material; in part by deficient metallurgical skill, as shown in the faulty construction of furnaces and the wrongly made up charges. The results, short campaigns, rich slags and a great loss in metal by dusting and volatilization, cannot be wondered at, if it be remembered that twenty-five years ago, even in the old European silver-lead works, the practical smelting was regulated more according to rule of thumb than underlying principles.

In the West, however, the opening-up of new resources of mineral wealth stimulated fresh energy to overcome these difficulties and obtain better results. The first independent improvement to which attention must be called was the invention of the syphon-tap by Mr. A. Arents‡ in 1871, which entirely changed the manner of removing the products from the Pilz and Raschette furnaces, the prototypes of our modern constructions. About 1876 a new era of lead-smelting was ushered in by the researches on typical lead-slags by Mr. A. Eilers in Utah and the introduction of water-jackets. By determining for each ore in what definite proportions silica, iron, and lime should combine to form a suitable slag, and ar-

* Mining Commissioner's Reports, 1870, p. 177; 1871, p. 119; 1872, p. 171.
† Mining Commissioner's Reports, 1869, p. 168; 1871, p. 218; 1872, p. 300.
‡ Transactions American Institute of Mining Engineers, vol. i. page 108.

ranging the charge accordingly, smelting was put on a scientific basis as different as possible from the purely empirical efforts of earlier times. By substituting water cooled jackets for fire-brick at the smelting-zone the life of the furnace was prolonged and the greatest freedom given in the selection of the typical slag to be formed. Of this second period Leadville,* Col., is the best type. Smelting was being slowly perfected, but the loss in metal was still great.

During the last ten years the tendency has been to separate the smelting works from the mines, and to erect large plants in places centrally located for the supply of ores, fluxes, and fuels. Thus to Leadville, which was the great centre, have been added Denver and Pueblo in Colorado. In the same way Salt Lake City, Ut., Great Falls, Mont., Omaha, Neb., Kansas City and Saint Louis, Mo., have become the smelting centres, which together produce the larger part of the base bullion of the country.

The principal works that desilverized base bullion were at first located on the Atlantic coast, e.g., the refineries of New York, Philadelphia, Newark, N. J., etc., the one important exception being a refinery at San Francisco.† It was not long. however, before desilverizing works were erected farther west, and to-day the bulk of the base bullion is refined between Chicago and the Missouri River, the process used being that of Parkes. This tendency to erect the refineries near the smelting works is showing itself now as far west as Colorado, where desilverizing works are being put up by smelting companies, thus diminishing greatly the cost of treatment and putting a finished product directly on the market.

In the discussion of the present practice of smelting and refining, only the main points ‡ can be taken up. The general form of blast-furnace used for smelting ores is about the same at all works. It is oblong, the sides are slightly inclined, the smelting zone has a bosh and is water-jacketed, the crucible is internal, and the lead is discharged through the Arents syphon-tap. Circular furnaces are only to be found in refining works for smelting, at intervals, small quantities of by-products. Even there they are giving way to oblong furnaces, because the smelting capacity of the circular furnace is limited by the diameter at the tuyères, which practice has now settled shall not be greater than 42 inches, the common measurement being 36 inches. The length of the oblong furnace at the tuyère-section varies from 86 to 120 inches, and the width from 30 to 42 inches. These two figures for the width represent the views of the two opposite schools in smelting, low-pressure (¾ and 1-inch quicksilver) and high-pressure (2 and 2½-inches quicksilver) blast. On the strength of the blast depends the height of the furnace, i.e., the distance from tuyères to the feed-floor, from 12 to 18 feet; the bottom of the crucible is about 30 inches below the level of the tuyères. A furnace 33 by 100 inches at the tuyères, with five ¾-inch tuyères on either side and 12 feet active height, will smelt, with 1⅛ inches quicksilver pressure, about 60 tons of medium-coarse charge. The shaft of the furnace, built to-day much thicker than formerly, rests on a cast-iron plate which is supported by eye-beams bolted to each other and to the capitals of the four supporting pillars. By this

*A. Guyard, "Argentiferous Lead Smelting at Leadville" in S. H. Emmens' "Geology and Mining Industry of Leadville, Col.," Monograph XII, U. S. Geological Survey, Washington, 1886.

† Mining Commissioner's Report, 1871, p. 458.

‡ For a complete treatment of the subject see the writer's "Metallurgy of Lead and Desilverization of Base Bullion," Scientific Publishing Co., New York, 1892.

new arrangement its stability is greatly enhanced. The furnace either has feed-holes on the sides, where the gases pass upward through a chimney forming the continuation of the shaft, and are drawn off from it, or there is one feed-opening on the top of the furnace which is otherwise closed by a cast-iron plate, the gases being drawn off beneath through one or two openings in the shaft. The jackets, enclosing the smelting zone are of cast-iron or wrought-iron, occasionally cast-steel. The temperature of the cooling-water in the jackets may be raised by other devices than that of having the inlet close to the outlet. There has been little change in the construction of the hearth; one improvement worth mentioning is that the lead-well is enclosed by the crucible castings, and not bolted to them as was formerly the case. In this way the length of the inclined channel is shortened and the loss of heat diminished. In many instances the well has been removed from the middle of the side and placed nearer the slag-tap in order to facilitate the work in the crucible in case crusts form on top of the lead. The blast is supplied by Baker & Root blowers. At first the tuyère-pipes were inserted at the junctions of the cast-iron jackets, later in the middle of each jacket, to reduce the amount of leakage. As the most recent improvement the sheet-iron tuyère-pipes have been replaced by cast-iron tuyère-boxes, which are bolted tightly to the jackets, and receive the blast through the ordinary canvas bags from the bustle-pipe surrounding the furnace.

Considerable variety exists in the slag-pots. Without going into the details of the many small improvements which aim to strengthen them and facilitate handling, three forms of slag-pots may be mentioned: the ordinary pot, which is wheeled on to the dump, allowed to cool there, and the corn of slag rolled out and broken up to separate slag, matte, speiss, and any lead that may have run out of the slag-tap; the overflow pot, which retains matte, speiss, and lead, and delivers clean slag into an ordinary pot to be discharged in the liquid state over the edge of the dump; and the catch-pot, with tap-hole near the bottom, which retains all the by-products and impure slag: finally, the large receiving-pots, holding nearly thirteen hundred pounds of liquid slag, deserve to be mentioned; they serve in large plants to facilitate the handling of valueless liquid slag, being drawn by power to the edge of the dump and emptied there.

As to the general form of the blast-furnace, it may be pretty confidently asserted that it will undergo no radical change, whatever improvements may be made in matters of detail. One of these may be the replacing of the water-jackets wholly or in part by a suitable refractory material, as the cooling water consumes a large amount of heat; e.g., a furnace 36 by 92 inches at the tuyères, requires per minute eleven gallons of water, the temperature of which becomes raised from say 15° C. to 70° C. The desired refractory material may prove to be the coke-brick which has lately been successfully used in the iron blast-furnace.

As to the general arrangement of the plant, great improvements have been made since smelting has been concentrated in a few large works. If the best examples of ten or more years ago, as described by Mr. A. Guyard in his report on the smelting of argentiferous lead ores at Leadville,* be compared with a modern plant, the difference will strike even the non-professional reader. All appliances for the receiving, sampling, and general handling of materials (ores, fluxes, fuels, inter-

* See Emmons, *op. cit.*

mediary or finished products) are now of such a character as to reduce labor and time about one half. It may be said that while ten years ago it took two men to smelt a ton of ore, one man is sufficient for the purpose now. The actual running of the furnace has been brought in this country to a degree of perfection which does not exist anywhere else.

As the beautiful carbonate ores are becoming scarcer, and being slowly but surely replaced by sulphide ores, the smelting-works have been forced to add to their plants separate departments for roasting. The important improvements in the long-hearth roasting furnace, which is the one in common use, have been increasing the width from 10 to 14 and 16 feet, and carrying on the roasting on a hearth separate from that on which the slagging or fusing takes place. The ore from the roasting-hearth is made to drop through a vertical flue, say from 22 to 24 inches high, into the slagging-hearth. Thus the two parts of the operation are separated, and the troublesome transition stage is avoided. In this way much labor is saved, and the wear and tear of the furnace considerably reduced. Hand-work has been in some instances replaced by machine work, the O'Hara furnace in a modified form having been introduced during the last two years. The roasting, with subsequent fusion of ores running low in lead, say 10 per cent, is a new feature, quite different from the European practice, where galena concentrates with from 55 per cent to 60 per cent of lead are the common material for the calciner. The prevalence of low-grade ores in which pyrite, blende, etc., predominate over galena, has necessitated, in this country, the use of new roasting-charges, by which some of the difficulties, at least in part, and the inevitable loss in silver and lead are reduced. A furnace with a roasting-hearth 14 by 60 feet will slag-roast from two to three tons of charge in twenty-four hours. The presence of blende and other deleterious substances is also a source of much trouble. A process which would successfully free lead ore from zinc would make much ore available that is of no value now.

As regards the best fuel for the blast-furnace, there is a diversity of opinion. Many metallurgists will use a mixture of coke and charcoal whenever they can; others will never use charcoal except with carbonate ores, especially if these be rich in manganese; some condemn charcoal entirely, and confine themselves to coke. In a few cases bituminous coal or even anthracite has been used to replace part of the coke.

The treatment of blast-furnace products is less advanced than would be expected from the general improvement in other departments. This of course does not include base bullion and slag. With the former, which will be discussed further on under desilverization, the difficulties caused by the uneven distribution of silver, gold, and impurities have been overcome by new ways of sampling, in some of which the machine has replaced the hand. The handling of slag has been already discussed. The three other products are speiss, matte, and flue-dust. The correct treatment of speiss is still a somewhat unsettled matter. Matte is roasted and concentrated in the blast-furnace to about 60 per cent copper, and then, as a rule, sold to copper-works which pay for no lead and only for 93 per cent of the silver, and demand a high price for refining. Some lead-works have begun to convert the copper matte into a finished product, instead of shipping it to copper-works. The last product, flue-dust, is the great bugbear. Wet condensation has

been about given up, and dry condensation is the method now used to recover the metal carried off from the furnace, but much still remains to be done in this direction.

The largest amount of lead recovered from furnaces treating charges low in lead is 94 per cent, while the conditions must be exceptionally unfavorable if the silver saved does not exceed 95 per cent.

The cost of smelting an ore varies greatly with its mineralogical character, the composition of available fluxes and fuels, the price of labor, the capacity and number of furnaces of a given plant, and last, but not least, on the skill of the metallurgist and the efficiency of the management. Any general estimate must therefore be adapted to local conditions. The following estimate of cost* refers to the smelting of a lead ore in a single furnace, 33 by 84 inches at the tuyère-section. The furnace puts through in twenty-four hours 48 tons of ore and requires 33 per cent flux (iron ore and limestone) and 18 per cent fuel (coke).

Materials.—16 tons flux at \$3.00, \$48.00; $11\frac{7}{11}$ tons coke (18%) at \$12.00, \$132.77; 3 cords wood at \$6.00, \$18.00; supplies, etc., \$12.50; total, \$211.27.

Pay-roll.—Superintendent, \$11.70; assayer, \$5.00; foreman, \$5.00; weighmaster, \$2.50; 2 engine-men at \$3.00, \$6.00; 3 furnace-men at \$3.00, \$9.00; 4 slag-men at \$2.50, \$10.00; 3 feeders at \$3.00, \$9.00; 4 charge-wheelers at \$2.50, \$10.00; 8 laborers at \$2.00, \$16.00; 2 inside laborers at \$2.25, \$4.50; 1 sampler, \$2.50; 2 bullion-men at \$2.00, \$4.00; total, \$95.20, and adding materials, \$306.47. For unforeseen expenses, 5 per cent, and delays in repairing furnace, 5 per cent, add \$30.65; cost of smelting 48 tons of ore, \$337.12; cost of smelting one ton of ore, \$7.03.

This estimate calls for eight-hour shifts for furnace-men and feeders, while for the same rate of wages twelve-hour shifts are not uncommon. Roasting is not allowed for, although it may be necessary and will cost about \$2.00 per ton; nor is the working-up of by-products (matte, flue-dust) considered.

The Desilverization of Base Bullion.—Only the Parkes process need be considered, as there is but one relatively small refining plant (Eureka, Nev.) which uses the Luce-Rozan or Steam-Pattinson process. All refining-works are built in terrace-form, and are so arranged that the base bullion, which has necessarily to be handled while being unloaded, sampled, and charged into the softening furnace, shall run from one furnace into the other and not be lifted again until it is loaded as refined lead into the cars to be shipped. The tendency of refiners has been to increase the number and capacity of furnaces and simplify construction, to reduce the amount of labor and material required and the loss in metal, and to hasten as much as possible the working up of by-products. As of the three operations, softening, desilverizing, and refining, the desilverizing under normal conditions takes the longest time, i.e., eighteen hours, the capacity of the kettle in which it takes place must regulate the size of both the softening and refining furnaces. The kettles are spherical, and made of cast-iron; they are from 3 ft. to 3 ft. 4 in. deep, with a diameter increasing according to the required capacity. At first they held fifteen tons of softened base bullion, later twenty tons; now the largest circular ones hold thirty tons. With a capacity of from forty-five to fifty tons, they are made oblong with rounded ends. The softening and refin-

* Hofman, "Metallurgy of Lead," page 294.

ing furnaces are both built into pans of boiler-iron, which rest on rails laid transversely over two or three longitudinal walls. They are of the same size externally, the bottom of the refining furnace, however, is made shallower than that of the softening furnace, on account of the reduced amount of lead it has to hold. To counteract the corrosive action of the lead the furnaces are water-cooled, preferably on the sides alone, but sometimes also on the bottom. The work of running a plant has been much simplified by letting the three operations, in contract, as a whole, sometimes even adding a fourth—that of moulding the refined lead. The consumption of materials (refractories, iron, and fuel) has been much reduced by perfected construction of apparatus and careful management.

The working up of by-products and zinc-crusts is open to considerable improvement. The liquated softening dross still goes back to the ore-blast furnace, the hard lead resulting from smelting liquated softening skimmings contains too much silver, and the refinings skimmings either give a second-class lead, if treated in the reverberatory furnace, or introduce zinc into the ore-blast furnace, if smelted there. Some improvements are already in progress, others have still to be worked out. The distillation of zinc-crusts, which is thus far the common method of working, is very unsatisfactory, but relief even from this is under way by the inventions of Dr. Roessler, who, by the addition of a small amount of aluminium to the zinc used in desilverizing, forms a rich zinc-silver-aluminium crust, practically free from lead, which he electrolyzes. He thus recovers the zinc, and has to refine only his silver in a crucible or cupelling furnace, as the case may demand. Of all the furnaces used for distilling that of Faber du Faur has found most favor, as it is easy to keep at a uniformly high heat, and the retort, when the distillation is finished, can be quickly emptied, cleaned, and refilled for a new operation, and its life thus greatly lengthened. Retorts which held at first 250 lbs. of liquated zinc-crust have been increased in size to hold 1000 lbs.

In cupelling the retort-bullion the English furnace is in universal use, but it has undergone many changes in construction, and also some in the manner of operating. The test, formerly an oval ring 4 ft. by 2 ft. 6 in., has been in some cases increased to 6 ft. by 3 ft. 8 in.; the original wrought-iron hoop has been in many instances replaced by a cast-iron ring, or, if wrought-iron has been retained, either water-cooled coils have been added to counteract the corrosion of the litharge, or the ring has been replaced on three sides by wrought-iron jackets and at the front by cast-iron jackets of different constructions. The support of the test formerly fixed has in many cases been made movable, so that during the process it can be moved up and down, and often also sideways. The filling material, originally bone-ash, has been replaced by a limestone-clay mixture, by pure cement, or a mixture of coarsely ground fire-brick and cement. The mode of working, at first a single operation, is now generally divided into two: concentrating the retort-bullion to sixty or eighty per cent silver in one furnace, and finishing the operation, including the fining of the silver, in another. By this means the concentration in water-jacketed tests, which is an easy operation, has been made continuous, while the finishing, requiring special skill, need be done only at intervals.

The output of metal in Parkes' process is on the whole a good one: the yield of silver is not under 99½%. Generally there is a surplus, as the loss in the refin-

ery is smaller than that which takes place in cupelling the base bullion in the assay office: that of gold is from 98% to 100%; that of lead from 99% to 99½%.

A detailed estimate of cost for desilverizing according to Parkes' process cannot be given, as the items vary at every plant. It may be said in a general way, that the operating expenses vary from $5 to $6 per ton of base bullion, while the total cost, including *all* general expenses, is just about twice this amount.

MANGANESE.

By R. A. F. Penrose, Jr., Ph.D.

The production of manganese ore in the United States in 1892, independent of manganiferous iron ores, manganiferous silver ores, and manganiferous zinc ores, was about 17,000 long tons. The production for the census year 1889 was 24,197 long tons, valued at $240,559, or $9.94 per ton; while the largest annual production in this country was that of 1887, when 34,524 long tons were mined. The total production of manganese ore in the United States from the time it was first mined, over 30 years ago, up to Dec. 31, 1892, has been almost 300,000 tons. As the United States consumes annually something over 50,000 tons of manganese ore in the various industries to which this material is applied, during the year 1892 it produced less than 50% of its consumption. The remainder came mostly from Cuba, Canada, Russia, and Chile.

Manganese has been found in many places in North America, but it has been mined profitably in only a few of them. At present Virginia, Georgia, Arkansas, Colorado, and to a lesser degree California and the Canadian Provinces of New Brunswick and Nova Scotia, furnish practically the entire output of the United States and Canada. Vermont has in the past produced a considerable amount of manganese and manganiferous iron ores, but at present its mines are idle. Small quantities have also been mined in Pennsylvania, Tennessee, North Carolina, South Carolina, Missouri, Michigan, and Nevada, but the production of these States has been insignificant. Manganese occurs in Central Texas, but no ore has been shipped from that region; it has also been found in Alabama, though no important deposits have yet been developed. Besides the United States and Canada, important deposits of this ore occur in the eastern part of Cuba, while Chile exports annually considerable quantities from a range of hills along the coast known as Cordilleras de la Costa.

Production.—Virginia, up to the present year, has always been at the head of the manganese producers of this country. Georgia has usually been second, with Arkansas third. In 1892, however, Arkansas produced probably more than Virginia, and considerably more than Georgia. The production of Virginia in 1892 was unusually small, being only about 5000 tons. This was due to the fact that the principal producer in that State, the Crimora mine, was closed the larger part of the year. The production of Georgia was about 2000 tons. In Arkansas there

was unusual activity, and the production was about 6000 tons, which is more than that State ever produced before in any one year. Colorado produced about 4000 tons of ore, containing from 25% to 40% of manganese. In Canada, which usually furnishes an important quantity of the ore, only about 85 tons were mined in 1892, and this amount came from the Provinces of New Brunswick and Nova Scotia and from the Magdalen Islands. The island of Cuba shipped about 18,000 tons in 1892.

The above six regions, therefore,—that is, Virginia, Georgia, Arkansas, Colorado, Canada, and Cuba,—produced in 1892 about 35,085 tons of manganese ore, which quantity represents almost the entire manganese production of North America in 1892. Chile probably produced half that amount, but the exact returns from the Chilean mines are not yet available.

Manganese was first mined in the United States in Tennessee, in 1837, but the production was small, and the amount mined there and elsewhere in the United States previous to 1880 is very uncertain.

In the following table the figures for years previous to 1880 are estimated from the best data available; for 1880–90 the figures are those compiled by Mr. Joseph D. Weeks, and are taken from the *Mineral Resources of the United States*, 1889 and 1890. The statistics for 1891 are advance figures from the Bureau of Mineral Statistics, and those for 1892 were collected by the author.

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES.

Year.	Virginia, Long Tons.	Arkansas, Long Tons.	Georgia, Long Tons.	Other States, Long Tons.	Total, Long Tons.
Previous to 1880	18,000	200	19,950	6,850	45,000
1880	3,661	....	1,800	300	5,761
1881	3,295	100	1,200	300	4,895
1882	2,892	175	1,000	375	4,532
1883	5,355	400	......	400	6,155
1884	8,980	800	......	400	10,180
1885	18,745	1,483	2,580	450	23,258
1886	20,567	3,316	6,041	269	30,193
1887	19,835	5,651	9,024	214	34,524
1888	17,646	4,312	5,568	1,672	29,198
1889	14,616	2,528	5,208	1,845	24,197
1890	12,699	5,339	749	6,897	25,684
1891	16,248	1,650	3,575	1,943	23,416
1892	5,000	6,000	2,000	4,000	17,000

The following table, quoted from the *Mineral Resources of the United States*, 1889–90, shows the production of manganese in the world in 1888 and 1889:

PRODUCTION OF MANGANESE IN THE WORLD.

	1888.	1889.		1888.	1889.
Russia (Caucasus)	48,653	60,000	Italy	1,652	400
United States	29,198	24,197	Cuba	1,581	4,000
Chile	24,746	5,000	Nova Scotia	106	200
France (1886)	7,676	......	New Brunswick	1,094	1,000
Sweden	6,089		Quebec	3	.. ..
Portugal	5,638	18,000	Great Britain	13,054	10,000
Spain	2,830		Bosnia	4,000	2,000
Australia	1,572	9,000	Holland	1,107	800
New Zealand	787	......	Other countries	3,114	1,000
Turkey	669	8,000			
Greece	385	400	Total	153,954	143,997

The Ores of Manganese.—The metal manganese occurs in nature in a great number of different forms, but the only ones that are, according to present standards, applicable to any considerable extent in the arts, are the oxides and the carbonates. The latter, though of frequent occurrence in small amounts, are so rarely found in large quantities in America that the oxides represent practically all the ores of manganese now used in this country. Besides these, numerous other manganese-bearing minerals are found, which, on account either of their chemical composition or of their limited quantity, are not available as sources of manganese. In some special cases, where such minerals are worked as a source of other metals, their residue has been profitably used for its contents of manganese. This is the case with the zinc ores of Northern New Jersey, which contain a considerable percentage of manganese, and, after the extraction of the zinc, the residue is used in the manufacture of spiegeleisen.

The most common of the manganese-bearing minerals, with the exception of the oxides and carbonates, contain manganese in the form of silicates, and are not used as a source of the metal in this country on account of their high percentage of silica. In some of these compounds manganese is the only metal, but in most of them it is associated with greater or less quantities of iron and other substances. The simple silicate of manganese, known as rhodonite, is the most abundant of this class of minerals, and is a common constituent of crystalline rocks. Among the others are the several manganiferous minerals of the olivine group; the manganiferous forms of augite, hornblende, and garnet; the manganiferous form of magnesian mica known as manganophyllite; the manganiferous epidote known as piedmontite; the manganiferous form of staurolite, and the manganiferous minerals in the chlorite group, such as prochlorite and others; the manganiferous pectolite known as mangano-pectolite; the alumina-iron-manganese-lime silicate known as ilvaite or lievrite, and many other rarer silicates. The sulphides, arsenides, phosphates, borates, and tungstates of manganese, as well as other compounds of the metal, also occur in nature, but in quantities too small to be of commercial value.

The oxides of manganese, which comprise practically all the manganese ore mined in this country, include several distinct minerals—pyrolusite, polianite, psilomelane, braunite, manganite, hausmannite, wad, pyrochroite, chalcophanite, pelagite, and manganosite. Of these the only ones found in quantities of commercial importance are pyrolusite, psilomelane, braunite, and manganite. Pyrolusite is the peroxide of manganese, having the formula MnO_2; psilomelane is composed largely of peroxide of manganese with varying amounts of water, potash, and baryta; braunite consists sometimes of the sesquioxide of manganese, having the formula Mn_2O_3, while at other times it consists of the same sesquioxide containing over eight per cent of silica, which is supposed by some mineralogists to be chemically combined with the sesquioxide. Manganite is the hydrous sesquioxide of manganese, having the formula $Mn_2O_3.H_2O$. All these four ores are of a black color, and frequently crystalline, with the exception of psilomelane, which is always massive.*

* For a fuller discussion of manganese ores, as well as of the manganese deposits of the United States and Canada, see *Manganese: Its Uses, Ores, and Deposits*, by R. A. F. Penrose, Jr., published as vol. i. of the *Annual Report of the Geological Survey of Arkansas for* 1890, J. C. Branner, State Geologist.

The oxides of manganese in this country are almost always associated with greater or less quantities of each other. One variety blends into the other, and it is often impossible to draw any sharp line of separation between them. So intimate a mixture is often found that it is difficult to decide, without a very careful analysis, to which variety a certain ore should be assigned.

The oxides of manganese mix with each other, and are often associated with oxide of iron, forming a ferruginous manganese ore; sometimes manganese ores contain such quantities of silver as to be more valuable for their contents of that metal than for their manganese. In some places also, as in Northern New Jersey, manganiferous zinc ores occur, which are valuable for both their zinc and their manganese.

ANALYSES OF CAR-LOAD OR CARGO SHIPMENTS OF MANGANESE ORES FROM DIFFERENT REGIONS.

Grade.	Locality.	Manganese	Iron.	Silica.	Phosphorus.	Moisture in Sample as taken.
High Grade	Chile	50.370%	2.320%	8.950%	0.014%	0.370%
	Chile	53.581	0 660	6.630	0.022	0.350
	Cuba	49.015	1.650	8.400	0.069	6.000
	Cuba	50.644	2.740	7.760	not made	4.000
	Nova Scotia	47.174	1.980	7.800	0.012	2.500
	Crimora, Va	49.163	1.750	9.800	not made	6.000
	Crimora, Va	48.530	1.985	10.200	0.103	3.000
	Crimora, Va:	50.541	1.957	10.120	not made	3.000
	Crimora, Va	48.162	4.568	10.300	0.095	3.000
	Arkansas	52.721	3.857	2.440	0.198	4.000
	Arkansas	50.142	3.505	2.950	0.165	3.000
	Arkansas	53.023	1.907	1.700	0.352	3.000
Medium Grade	Georgia	41.248	9.100	14.400	0.109	2.000
	Georgia	41.630	1.990	10.820	0.050	4.000
	Georgia	42.856	10.491	7.300	0.139	6.000
	Georgia	44.308	4.595	10.950	0.156	6.000
	Virginia	43.379	9.633	9.750	0.068	4.000
	Virginia	43.612	6.650	10.480	0.221	1.500
	Virginia	42.953	14.850	3.600	0.184	6.000
	South Carolina	45.018	2.750	8.100	0.085	9.000
Low Grade	Virginia	37.693	12.368	10.600	0.153	9.000
	Virginia	28.311	27.830	4.460	0.067	4.000
	Virginia	35.362	20.950	6.250	0.780	5.000
	Virginia	36.028	8.703	16.380	0.113	7.000
	Virginia	33.599	16.588	14.750	0.095	3.000
	Georgia	34.157	13.590	12.900	0.167	8.000
	Georgia	36.179	7.078	16.400	0.053	1.000
	Georgia	39.893	10.210	12.720	0.106	6.000
	Vermont	20.369	31.648	12.770	0.125	5.000
	Vermont	19.706	29.268	14.000	0.145	8.000

* This table is quoted from vol. i. of the *Annual Report of the Geological Survey of Arkansas* for 1890, already referred to.

The Manganese Deposits of the United States, Cuba, and Canada.—As already stated, the most important manganese localities in the United States are Virginia, Georgia, Arkansas, and Colorado, while less important are those of Michigan and California, and still less those of Vermont, Pennsylvania, Tennessee, North Carolina, South Carolina, Alabama, Missouri, Nevada, and Texas.

Vermont.—Manganese mining was begun in Vermont at several places before 1861, and limited quantities of ore have been produced intermittently since that time. Brandon and South Wallingford have been the principal centers of production, though small quantities have also been obtained from Chittenden, Bennington, and elsewhere. The Vermont manganese mines were all idle in 1891 and 1892. The manganese ores of Brandon and South Wallingford occur in regions of Cambrian rocks. At South Wallingford they are found in lumps, in a clay which has resulted from the decay of a rock stratum inclosed between Cambrian sandstone and quartzite. At Brandon they occur in Tertiary beds, which have probably

resulted from the rearrangement, in Tertiary times, of materials from the same, or almost the same, geologic horizon as at South Wallingford. The deposits at these two localities form part of an iron and manganese bearing belt which extends down the great Appalachian Valley from Northern Vermont through Pennsylvania and Virginia and southwestward to Alabama.

New York and Pennsylvania.—New York has never been a producer of any considerable quantity of manganese ore, while a few hundred tons from Pennsylvania, mostly from Lehigh County, would cover the production of that State.

New Jersey.—The manganiferous zinc ores of Franklin and Sterling, N. J., have been used as a source of spiegeleisen since 1874. After the extraction of the zinc they contain, the residuum, known as "clinker," is treated as a manganese ore. Between 40,000 and 50,000 tons of these manganiferous zinc ores are mined annually.

Virginia, Georgia, and Adjoining States.—The principal manganese-producing region of the Atlantic States lies on the western slope of the Blue Ridge, between the Potomac River on the north and the head-waters of the Alabama River on the south. This belt includes the well-known mines of Virginia, Georgia, and other localities in the intermediate States.

Most of the deposits of Virginia are in the Valley of Virginia, though others are found in the New River and Cripple Creek region, and even still farther west; manganese ore has also been mined in the James River Valley and in the coastal area of Virginia. Geographically speaking, the deposits of the Valley of Virginia are traceable southwestward through East Tennessee, the western parts of North Carolina and South Carolina, and into Georgia and Alabama, where they culminate in the Cartersville region, Georgia. Over 200,000 tons of manganese ore have been produced in this belt since mining was first begun. Of this amount about 160,000 tons were from Virginia, of which the Crimora mine supplied about 140,000 tons. This mine and the several mines in the Cartersville district of Georgia are the most important manganese localities in the Atlantic States, while Tennessee, North Carolina, South Carolina, and Alabama have produced practically insignificant quantities of the ore.

The Crimora mine is in Augusta County, in the Shenandoah Valley, seven miles northeast of the town of Waynesborough. It has been worked at intervals since 1867, and has produced in all about 140,000 tons of ore. For a number of years ending April 30, 1892, this mine was operated by the American Manganese Company; but on May 1, 1892, it passed into the hands of the Crimora Manganese Company. The former company produced 3126 tons from the mine from Jan. 1, to April 30, 1892. When the property passed into the control of the Crimora Manganese Company operations were suspended five or six months, but in October mining was resumed, and at the end of the year the output was averaging about 20 tons daily. The total production of the Crimora mine for 1892 was probably not much over 4000 tons. Elsewhere in Virginia manganese has been produced at Lyndhurst, Buena Vista, and Houston; at the Cabell and Bagley mines, in Nelson County, near Mount Athos, and at many other places; but the production has been small as compared with that of the Crimora mine.

In Georgia the manganese deposits are situated in the northwestern part of the State, mostly in Bartow County, with less important deposits in Polk, Floyd,

Whitfield, and other counties. The manganese production of Georgia in 1892 was about 2000 tons, and the production of the State since mining first began in 1866 up to Dec. 31, 1892, has probably been over 60,000 tons.

The manganese ores of the Appalachian region, extending from Vermont to Georgia, occur in rocks of several different geologic ages from Archæan to Tertiary. In fact, manganese characterizes many of the iron-ore belts throughout this area; but the only deposits that have been worked to any considerable extent as a source of manganese are in the Cambrian and Silurian rocks, and especially in the areas of Cambrian quartzite and the immediately overlying limestones or shales.

Speaking geographically, the main manganese-bearing stratum, which in different places may be represented by either manganese or iron, or both, skirts the western and northwestern slopes of the pre-Palæozoic crystalline rocks, and passes through the Appalachian Valley from Northern Vermont to Alabama. It runs along the eastern side of Lake Champlain, through the Cumberland Valley of Pennsylvania, the Valley of Virginia and East Tennessee, the western parts of North Carolina and South Carolina, the northern part of Georgia, and into Alabama, where it finally disappears under the Cretaceous and Tertiary strata of the lower Mississippi Valley. In this belt the most prominent manganese deposits occur in a residual clay, in or overlying a quartzite bed which is frequently, if not generally, of Cambrian age; in some cases it may be of Silurian age. Some of the Georgia deposits also, especially in Polk and Floyd counties, occur in Lower Silurian chert or cherty limestone. The principal deposits in Georgia, however, which are those in Bartow County, occur overlying quartzite.

The ores throughout the Appalachian region are usually found in irregular pockets, masses, or nodules in clay. This clay has been derived from the decay of a rock stratum of a shaly, sandy, or calcareous nature, which originally carried the ore in much the same form as it now exists in the clay. In some cases, however, the ore still occurs in the original rock.

Arkansas.—The manganese deposits of Arkansas occur in (1) the Batesville region, in the northern part of the State, and (2) in the southwestern part. The only commercially important deposits, however, are in the Batesville region, which is situated in the valley of the White River. It includes a territory of about 122 square miles, in which manganese occurs intermittently. Next to the Virginia and Georgia regions, the Batesville region has produced more manganese ore than any other locality in the United States. The total production since mining was begun has been 40,000 tons or over. This has been produced since 1850, though over 90% of it was mined between 1881 and 1892. Over half the production of the Batesville region has been supplied from the Southern mine, which is the property of the Keystone Manganese and Iron Company.

The manganese deposits of the Batesville region occur in an area of Silurian and Carboniferous rocks. The ores are found in a red clay, which has resulted from the decay of a crystalline Silurian limestone, known as the St. Clair limestone, and called by the miners "gray rock." The deposits are usually capped by a mass of broken chert from 1 foot to 50 or 60 ft. in thickness. This rock is of Lower Carboniferous age, and represents the remains of a solid stratum which originally overlaid the St. Clair limestone. When the limestone decayed, the chert sank down on the residual clay left by the limestone and became distorted

and shattered. The ore in the clay occurs in much the same way as it did in the original limestone; that is, in irregular pockets, masses, sheets, or as scattered nodules. Sometimes the clay is barren of ore for considerable distances; at other times the ore is abundant. In some places, where the limestone has not decayed, the ore can still be seen in it *in situ.* The rocks of the region lie almost horizontally, and the ore deposits usually occur on the summits or slopes of the hills.

The other manganese-bearing area of Arkansas extends intermittently from Little Rock westward to Indian Territory, including Pulaski, Montgomery, Polk, and other counties, comprising an area of about 125 miles in length and from 4 to 12 miles in width. Manganese has not been found in this belt in commercially important quantities, and not over 30 tons have been shipped. The ore occurs in novaculite (a siliceous rock) of Lower Silurian age.

Missouri.—The manganese region of Missouri is in the Archæan area, in the southeastern part of that State, about 125 miles north by east from the Batesville region of Arkansas. The ore has been worked to only a very limited extent, though small quantities have been taken out at the Culbertson bank, on Budford Hill, and elsewhere in Iron County. The deposits are in the same region as the celebrated Pilot Knob and Iron Mountain.

Michigan and Wisconsin.—Northward from Missouri, up the valley of the Mississippi, no manganese ore of importance has been found, though small quantities have been obtained in mining iron ore at the Colby and several other mines of the Gogebic Range, Michigan. Several deposits have also been prospected in Marquette, St. Croix, and Dunn counties in Wisconsin. Besides the manganese ore from the Colby mine, large quantities of manganiferous iron ore, containing from 2% to 11% manganese, have been mined at the same place for some years past.

Texas.—The manganese deposits of Texas are in the pre-Cambrian rocks of Mason, Llano, and San Saba counties, in the central part of the State, over 200 miles northwest of the coast of the Gulf of Mexico. They are situated from 40 to 60 miles from railway transportation, and have been only partly prospected. No ore has been shipped from them.

Rocky Mountain Region.—In the Rocky Mountains ores available as a source of manganese have not yet been mined, except in Colorado. Manganiferous silver ores occur in large quantities at Butte City, Mont.; Leadville, Col.; and Tombstone, Ariz., as well as at other places. The manganese in them is of value as a flux in silver-lead smelting, and is paid for accordingly at the various works, but it is generally too intimately associated with the silver to be used for other purposes without sacrificing the more valuable metal. Moreover, even if it could be used as a source of both metals, it is often of too low grade to be a desirable source of manganese. At Leadville and vicinity, however, considerable quantities of manganese and manganiferous iron ores are obtained from the silver deposits. These are sometimes used as a flux in silver-lead smelting, but considerable quantities are consumed as a source of spiegeleisen and ferro-manganese. In 1892 about 4000 tons of manganese and manganiferous iron ores were shipped from Leadville, and were consumed entirely at the steel works of the Colorado Coal and Iron Company at Pueblo. These ores contained from 25% to 40% of manganese.

Nevada.—West of the Rocky Mountains manganese has been found in the Humboldt Valley, three miles northeast of the settlement of Golconda, Nev. The ore occurs in a Pleistocene calcareous tufa deposited by the now extinct Lake Lahontan. It is of limited extent, and has supplied only a few tons of ore.

California.—The most westerly manganese deposits of the United States are in the coast ranges of California. Though this State has never been prominent as a large producer of manganese, it has since 1867 supplied limited quantities, amounting altogether to probably less than 10,000 tons. The principal deposits are in shales and jaspers, or "phthanites," of Cretaceous age. In California, as in Virginia and Arkansas, one mine has produced almost the entire manganese output of the State; in this case it is the Old Ladd or Corral Hollow mine, in San Joaquin County, which was opened in 1867, and up to 1875 produced 5000 tons of ore, with a smaller output since that date. Other localities in California, such as Red Rock and Saucelito, both near San Francisco, have been worked for manganese, but their production has been very small.

Cuba.—The manganese deposits of Cuba are in the eastern part of the island, to the north and west of Santiago de Cuba. There are three groups of deposits in this region, namely, the Christo to the north, and the Bayamo and Portillo to the west. The Christo has supplied most of the ore shipped from the island. The principal mines in the Christo group are the Boston, Isabellita, Ponupo, Marguerita, and Bosford, mentioned in the order of their importance, the Boston having afforded by far the largest production. The total shipments from the port of Santiago—which represent the total shipments from Cuba—up to March, 1891, were 27,051 tons. In 1892 about 18,000 tons were shipped. The whole of the Cuban production of manganese is consumed in the United States.

Canada.—The principal manganese deposits of Canada are in the Provinces of Nova Scotia and New Brunswick, and are situated mostly in the drainage area of the Bay of Fundy. They occur in the Marine limestone of the Lower Carboniferous series. Similar deposits also occur near Loch Lomond, in Cape Breton; while limited quantities were mined a number of years ago in rocks of Cambro-Silurian age at Tête à Gauche Falls, near Bathurst, in New Brunswick.

The first systematic manganese mining in Nova Scotia was done at the Tenny Cape mine, in Hants County, in 1862, and this work was soon followed (about 1864) by the opening of the Markhamville mine of New Brunswick under the direction of Major A. Markham. As a result of the energetic and able management of Major Markham, the latter mine was for a long time the leading one in Canada; but the past year it does not appear in the list of producers. Canada in 1892 produced only about 75 tons of manganese ore, though its usual annual production is generally at least several times this amount. Of the 1892 production, Nova Scotia supplied 50 tons, all of which came from the Tenny Cape district; New Brunswick supplied 20 tons, all of which came from the Hopewell district, in Albert County; and the Magdalen Islands supplied about 5 tons.

The manganese ores of the Bay of Fundy basin occur usually in limestones often containing shaly layers, and sometimes, though not always, dolomitic. The ore occurs in this rock in pockets, nests, and disconnected seams, varying from less than an inch to several feet in thickness. In a general way the ore tends to follow the bedding of the rock; and the present deposits, though they sometimes

cross the lines of bedding, have in all probability been derived from originally bedded deposits. When mining in this region was first begun considerable quantities of ore were obtained from a residual clay which had been formed by the decay of the ore-bearing limestone.

Chile.—Manganese ore, of which there are vast deposits, is mined in two districts—Coquimbo and Carrizal, or Huasco. As is generally the case in South America, the cost of transportation to the seaboard is a most serious item of expense. The Coquimbo ore, although it averages 52% in metallic manganese, and is easily and cheaply mined, being near the surface, has this serious difficulty to encounter. Delivered alongside in the harbor of Coquimbo, 35 to 40 miles distant, it costs from $5 to $7.50 a ton.

The Carrizal ore differs from that of Coquimbo in being much harder, and in not containing powdery masses. It averages 50% in metallic manganese.

The following table gives the Chilean production of manganese ore since 1885 in long tons (2240 lbs.):

Year.	Coquimbo.	Carrizal.	Total.
1885........	4,041	....	4,041
1886	23,701	227	23,928
1887........	38,234	9,287	47,521
1888........	12,132	6,581	18,713
1889........	9,145	19,538	28,683
1890...	23,409	24,577	47,986
1891...	16,462	18,000	34,462
Total ..	127,124	78,210	205,334

As a rule, the Chilean ores contain large quantities of the protoxide of manganese (to 20%), and the content in phosphorus is usually very low.

New Zealand.—The mining of ore, chiefly braunite, began in 1878, since which time one or two thousand tons have been exported each year.

Russia.—The production is increasing very rapidly, as in 1881 it was, in long tons, 11,044 ; in 1889, 76,687 ; and in 1890, 179,420.

United Kingdom.—Carbonate ore is mined in Merionethshire, Wales, and the annual production is about 10,000 tons.

Uses of Manganese.—Over nine tenths of the manganese production of the world is used in the manufacture of the alloys of iron and manganese, known as ferro-manganese and spiegeleisen, which are used largely in steel-making. The rest of the manganese production is used in making rarer alloys ; as a reagent in the manufacture of chlorine and bromine ; to decolorize, as well as to color, glass ; as a drier in varnishes ; as one of the elements in Leclanché's battery ; in the preparation of oxygen on a small scale ; in the manufacture of disinfectants (manganates and permanganates); in calico-printing and in dyeing ; in coloring pottery and bricks and in making paints ; as well as in numerous other minor industries.

The following table shows the amount and value of manganese, including manufactured oxide and oxide as ore, imported into the United States in the calendar years 1889, 1890, 1891, and 1892, in long tons.

Year.	Ore.		Manufactured.	
	Tons.	Value.	Tons.	Value.
		$		$
1889	4,135	72,391	151	6,000
1890	33,998	509,704	156	7,196
1891	28,624	371,594	201	9,024
1892*	12,502	212,310	64	2,895

* First half of the year.

Prices paid for Manganese.—The Carnegie Steel Company of Pittsburg has been for several years the chief purchaser of manganese ores in the United States. The schedule of prices during the month of December, 1892, for ore delivered is based on ores containing not more than 8% silica and not more than 0.10% phosphorus; they are subject to deductions as follows: for each 1% of silica in excess of 8%, 15c. per ton; for each 0.020% of phosphorus in excess of 0.10%, 1c. per unit of manganese.

Manganese.	Prices per Unit.		Manganese.	Prices per Unit.	
	Iron.	Manganese.		Iron.	Manganese.
	Cents.	Cents.		Cents.	Cents.
Ore containing above 49%	10	31	Ore containing above 32 to 36%	10	25
" " " 47 to 49%	10	30	" " " 28 to 32%	10	23
" " " 45 to 47%	10	29	" " " 24 to 28%	9	21
" " " 43 to 45%	10	28	" " " 20 to 24%	9	19
" " " 40 to 43%	10	27	" " " 16 to 20%	9	17
" " " 36 to 43%	10	26	" " " 12 to 16%	9	15

Settlements are based on analysis made on samples dried at 212°, the percentage of moisture in samples as taken being deducted from the weight.

These prices are subject to change without notice unless otherwise specially agreed upon.

MICA.

By William Allen Smith, E.M.

Composition.—The minerals known as mica are complex silicates of alumina, with other bases (iron, soda, potash, magnesia, and lithia), and occur in small scales, as a constituent of common granite, or in distinct crystals, sometimes three or four feet in diameter. The crystals of mica are right or oblique rhombic prisms, with short axes, and marked cleavage parallel to the base. The mica minerals are :

1. Muscovite, or potash mica. This is the most common variety, is known as white mica, and furnishes the transparent sheets for stove doors, etc. In thin sheets it is colorless ; in thick blocks, white, gray, brown, or wine-colored. Muscovite is much harder than any of the other mica minerals.

2. Biotite, or magnesia-iron mica. This variety is very common in Canada, and furnishes what is known as amber mica. Even in thin sheets it is only partially transparent, being highly colored with oxide of iron. Biotite is often found in small, very dark, even black, scales and crystals.

Muscovite and biotite are the only varieties of commercial importance.

Besides these there are (3) phlogopite, or magnesia mica, found mostly in crystalline limestone, and (4) lepidolite, or lithia mica.

Occurrence.—Mica (muscovite) in crystals large enough to make merchantable sheets occurs in veins or dikes of very coarse granite, usually in granitic country-rock, gneiss, mica-schist, porphyritic granite, etc. The quartz, mica, and feldspar of these veins of granite appear in large crystals or masses. The mica often occurs in regular strings of crystals parallel and near to the hanging or foot-wall. More frequently, however, the mica crystals are found in irregular bunches anywhere in the vein—especially noticeable where a vein "bellies"—or in off-shoots.

Mica veins often contain such minerals as beryl, tourmaline, garnet, columbite, and samarstite. Enormous beryls have been found in some of the New Hampshire mica veins. Mount Mica, near Paris, Me., is a celebrated source of tourmalines, etc. Cassiterite is an accompaniment of the mica deposits of the Black Hills, S. D.

MICA MINING IN THE UNITED STATES.

In the United States mica mining in quantity has been restricted to Grafton County, New Hampshire, and the western counties of North Carolina. In New Hampshire the principal supply has come from three mines—the Ruggles, opened early in this century, the Valencia, and the Palermo. The last is the only one now working, and is to-day the principal source of sheet mica in the United States.

In North Carolina the mines in Mitchell and Yancey counties, and in that neighborhood, flourished for some years after the war. Large quantities of excellent mica were mined and marketed up to 1886, and the name "North Carolina mica" still remains in the trade to designate first quality. Many of the North Carolina mines were reopenings of prehistoric workings of the mound-builders, who seem to have used it for ornamental purposes. Sheets and blocks of mica have also been found in the graves of warriors.

The North Carolina district is remote from railroads, and the mining has been crudely done. The production has been very large, though coming mostly from a few mines. In 1884 the value of the product reached $180,000.

Many mines have been opened in North Carolina and New Hampshire, which have had only a brief existence, and have not contributed materially to the supply.

Mica has also been mined to some extent in Dakota, Wyoming, and New Mexico, but neither in large quantity nor of a quality equal to the Eastern grades.

A deposit has quite recently been opened and worked near Cripple Creek, Col.

PRODUCTION OF MICA AND IMPORTS INTO THE UNITED STATES.

Years.	Production.		Imports, Value.	Year.	Production.		Imports, Value.
	Pounds.	Value.			Pounds.	Value.	
1869-1876	....	....	$6,124	1885	92,000	$161,000	$28,685
1877	....	....	13,085	1886	40,000	70,000	43,107
1878	....	....	7,930	1887	70,000	142,250	63,240
1879	....	....	9,274	1888	48,000	70,000	21,806
1880	81,669	$127,825	12,562	1889	49,500	50,000	91,826
1881	100,000	250,000	5,839	1890	60,000	75,000	146,975
1882	100,000	250,000	5,175	1891	75,000	100,000	110,442
1883	114,000	285,000	9,884	1892	75,000	100,000*	217,939
1884	147,410	368,525	27,555				

* No accurate returns for 1892 are available. The product for this year is estimated by the best authorities as follows: New Hampshire, $70,000; North Carolina, $25,000; other States, $5000. The small producers keep no records, and the larger ones attempt to make a mystery of their business.

From 1883–88 small quantities of mica were exported, amounting in the aggregate to $5682.

During the year 1892 large quantities of waste or scrap were made into ground mica, of which the production (not included above) amounted to 959,000 lbs., valued at $67,180.

The imports are for fiscal years ending June 30th.

Mica-mining in this country received a decided set-back, beginning in 1884, from the greatly increased imports. In that year mica was brought from India, and the imports have increased year by year. The Indian mica occurs in such large quantities, and can be mined so cheaply, that competition has been almost hopeless, in spite of the recent *ad-valorem* duty of 35% imposed by the McKinley tariff. The Indian mica is nearly equal in quality to the best North Carolina or New Hampshire grades.

Mica has also been largely imported from Canada during recent years. It occurs there in very large quantities, though of inferior transparency. The Canadian mica is mostly of the grade known as amber mica, and is largely used for electrical purposes.

MICA-MINING IN CANADA.

(For the following information we are indebted to Messrs. McRae & Co. of Ottawa, and to Prof. J. F. Donald of Montreal.)

Within the last eighteen months the mica-mining industry of Canada has assumed large proportions. This has been caused by the extraordinary demand for mica for electrical purposes. The Canadian deposits of amber mica are so large and so easily worked that they practically supply all demands which do not require transparency. The chief deposits are in Ottawa County. Mica-mining has very naturally succeeded phosphate-mining, a business now almost wiped out by the large production in Florida and the agricultural depression in Europe.

Apatite and mica are frequently associated in the Laurentian rocks, both minerals being often mined from the same pit, the mica occurring in large crystals in the phosphate. During the phosphate "boom" of a few years ago the large amount of prospecting opened up deposits of mica, now made valuable by the demand for electrical purposes. In addition to various individuals and private firms now engaged in mica-mining, several large companies are at work.

STATISTICS OF THE CANADIAN MICA INDUSTRY FOR 1887–92.

		Quantity.		Value.
1887.	Marketed	22,083 lbs.		$29,816
	Mined and cut	39,500 "		
1888.	Exports, cut and crude	21,851 "		21,127
1889.	" " "	36,529 "		28,718
1890.	Marketed production			68,074
1891.	" "			71,510
1892.	Exports to United States:			
	Ottawa, consular returns		$64,729.82	
	Brockville, " "		6,608.44	
	Kingston, " "		10,249.30	
	Montreal, " "		68,466.00	
	Prescott, " "		None	
			150,053.56	
	Exports to Great Britain (part ground)		544.00	
	" " Germany—ground mica		485.00	
				$151,082.56

SHEET MICA.

Uses and Sizes.—Mica in sheets has long been used for stove and furnace doors, for lamp-protectors, etc. Such mica must be clear and free from spots. The choicest mica for this purpose is that which in blocks is of a wine color. White mica is next to be preferred. The standard sizes range from $1\frac{1}{2} \times 2$ in. up to 8×10 in. The dealers publish a list of 193 sizes, the prices ranging from 40c. to $13 per lb. The discounts on the first quality of mica range from 40% to 60% and over, according to the state of trade and the demand for, or scarcity of, certain sizes. The smaller sizes are abundant and easily obtained, but they seldom pay the cost of mining and preparation. Mica for electrical purposes must be

flexible and non-conductive. Color does not matter, but perfect cleavage is of the highest importance, as "electrical mica" must be of uniform thickness, and is often gauged to the thousandth part of an inch. The sizes and shapes of sheets vary greatly, 450 different patterns having been called for. The price is from 10c. to $2.50 per lb., and varies with the size of sheet and difficulty of cutting the pattern.

Preparation.—Care is taken in mining to avoid drilling through the mica crystals, or to break them unduly. The mica thrown down by blasting undergoes a preliminary hand-dressing underground. It is then taken to the "mica shop," where it is split with knives into sheets of the required thinness, and afterward sheared into sizes. The workman has on his bench a stationary pair of shears and a large number of blocks or templates of the sizes to be cut. An experienced mica-cutter can tell at a glance the largest size which can be cut from a given piece of split mica; he selects the proper template, holds it on the mica, and shears the four sides, using each edge of the block as a straight-edge. Each size sheared is set away by itself. The sheets are cleaned by further scaling, if necessary, and finally packed in paper in pound packages. The production of merchantable sheets is usually from 4% to 5% of the block mica brought from the mine, and may run as high as 8% or 10%.

GROUND MICA.

In recent years the preparation of ground mica has become an industry of itself, and several firms have gone into the business. Waste or scrap mica is generally used. The difficulties of grinding are great, owing to the tough and scaly nature of the material. Mills which work well on almost everything else fail utterly on mica. Recently there has been a return to old-fashioned burr-stones, though most of the manufacturers keep their process a secret. The grinding is usually wet.

Ground mica is now largely used for purposes of decoration, as in the manufacture of wall-paper, where the coarsest grades are used to give a frosted and spangled effect, and the finest grades to form a metallic white surface. It is also used in making a lustrous hair powder, etc. Medium sizes of ground mica are used in the manufacture of lubricants for journals and axle-bearings. Some manufacturers grind mica to a very fine powder for "specialties," but the sizes of ground mica usually made are 24, 40, 60, 70, 80, 100, 140, 160, and 200 meshes to the inch, and the prices range from 5c. to 10c. per lb. Scrap mica for grinding is bought for about $12 per ton at the mine. It must be free from rust or specks, which would affect the color and luster of the product.

NICKEL AND COBALT.

By Walter Renton Ingalls, M.E.

The principal ores of nickel are the hydrous silicate of nickel and magnesia (garnierite or genthite) and nickeliferous pyrrhotite and chalcopyrite. Nickel also occurs in workable quantities as sulphide (millerite), arsenide (niccolite), and arseniate (annabergite). Cobalt minerals are associated intimately with those of nickel, particularly the sulphide, arsenide, and arseniate. Garnierite is a brittle mineral of apple-green color, and glinting to dull luster; millerite is brass-yellow in color, often with a gray iridescent tarnish; niccolite has a pale copper-red hue and metallic luster, its streak being a pale brownish red.

Occurrence.—The most important sources of nickel at the present time are the mines of New Caledonia and of Sudbury, Ontario; but mines are also worked in the United States, in Norway and Sweden, and in Prussia. There is but one locality —Lancaster Gap—in the United States where nickel is produced in important quantity at the present time, though a small amount is derived annually from Southeastern Missouri, and mines are being opened in Oregon and Nevada. Nickel has been discovered in a number of other States, and in several States mines were worked formerly, but only in the four places named above are active operations now being carried on.

Arkansas.—Nickel ore has been found at Benton, Saline County, where a mine has been opened to a depth of about fifty feet. The ore is millerite, but the deposit does not seem to be of any consequence.

Colorado.—Nickel arsenide and sulphide, associated with cobalt, have been found in some of the mines in the southern part of Fremont County, near Silver Cliff. Some shipments of ore rich in nickel have been made from the Gem mine to Swansea, Wales, in years past,* but recently the mine has been idle, though there have been reports that it was to be reopened.

Connecticut.—Nickel and cobalt minerals have been found at Chester, and the mines there, once held to be very promising deposits, are believed to have been worked originally by Governor John Winthrop,† who in 1651 received his famous license to work any mines of lead, copper, or tin, etc., and to enjoy the said mines

* *Production of Gold and Silver in the United States*, 1882, p. 444.

† Abram S. Hewitt, *Transactions American Institute of Mining Engineers*, 1876.

forever. The Chester mines have never been important, and are only of interest mineralogically.

Iowa.—A few months ago it was reported in the newspapers that nickel ore had been discovered in Iowa, concerning which Mr. Charles Rollin Keyes, Assistant State Geologist, writes as follows: "In quarrying near Keokuk recently, in the compact Keokuk limestone (Lower Carboniferous), some feet below the 'geode bed,' numerous cavities were encountered, varying from two or three to several inches in diameter. These cavities were studded with large, bright, and sharply-cut rhombohedral crystals of calcite, on some of which occurred tufts of needle-like crystals of millerite (nickel sulphide) from one half to two and one half inches in length. One specimen of calcite, covered thickly with matted needles of millerite, weighed over 50 pounds. It is believed that this is the first time that any of the nickel minerals have been reported from Iowa; but while of much interest from a mineralogical standpoint, it is improbable that the discovery will prove of any economical importance."

Massachusetts.—At Dracut, near Lowell, in Middlesex County, there is a deposit of nickeliferous pyrrhotite, which was opened early in 1877 by a company that erected smelting-works and ran them for a short time, producing a matte with about six per cent nickel and cobalt. The works were closed down in 1878, and nothing has been done at the mine since that time. Various reasons are assigned for the failure of this undertaking. It is said that the ore was refractory and of low grade, and that there was no one connected with the works familiar with the metallurgy of nickel.

Missouri.—The lead ores of the Mine La Motte, in Southeastern Missouri, contain a small amount of nickel and cobalt, associated with iron pyrites; these minerals are saved in the dressing-works, and in the subsequent smelting operations are collected in a speiss, which is sold to the nickel refiners. The amount of metal derived from this source is but trifling.

Nevada.—An ore containing sulphides and arsenides of nickel and cobalt is found in veins at Cottonwood Cañon, near Lovelock's Station. Mines are being opened there by the National Nickel Company, of New York, which has a small force of men at work developing the property. So far, it is said, results have been satisfactory as far as quantity of ore is concerned, but no shipments have yet been made. It is the intention of the company to erect smelting furnaces eventually, but at present all efforts are directed to a thorough exploration of the mines. Some years ago several lots of ore and matte were shipped by Mr. George Lovelock, Sr., who owns mines near those of the National Nickel Company. He also set up a small furnace in 1885, with which he turned out 34,000 lbs. of matte, assaying 36% nickel and 34% cobalt. The ore shipped amounted in all to about 300 tons, and assayed from 20% to 60% nickel.* Since 1886 but little has been done at these mines, except the annual assessment work to hold the claims, in the course of which several hundred tons of ore have been taken out.

North Carolina.—Superficial deposits of hydrous silicate of magnesia and nickel, resembling the garnierite of New Caledonia, and occurring in connection with serpentine country-rock, have been found at Webster, Jackson County. It

* *Eleventh Census Report on the Mining Industry*, p. 271.

has been frequently stated that these deposits are of identical character with those of New Caledonia; but although there are certain points of similarity, Mr. Stephen H. Emmens, in a careful paper published in the *Engineering and Mining Journal* of April 30, 1892, has called attention to important points of difference between the two. No regular mining has yet been undertaken in North Carolina, nor has any serious attempt been made to prove the value of the deposits.

Oregon.—Nickel ore has been found in Oregon in three localities, viz., on Piney or Nickel Mountain, near Riddles, Douglass County; on Upper Dad's Creek, in the same county; and near Rock Point, in Jackson County. According to Mr. Henry J. Biddle of the United States Geological Survey, the deposits at Upper Dad's Creek and at Rock Point are veins of pyrrhotite and chalcopyrite, containing about two per cent nickel and a small amount of cobalt. At Riddles the ore is found either in boulders disseminated through a highly ferruginous earth, or in a stratified bed underlaid by an altered serpentine. Occurring with the nickel ore (hydrous nickel-magnesium silicate) is chromic iron and chalcedony.

No ore has yet been shipped from this property, but during the past year the owner, the International Nickel Mining Company, of Chicago, has been making extensive preparations to begin production, erecting a smelting plant, saw-mill, and wire-rope tramway, laying out a brick-yard, and constructing about 6½ miles of wagon-road. There are about 3000 or 4000 tons of ore mined and piled ready for treatment, and the furnaces are expected to be in operation in February or March.

Pennsylvania.—The most important nickel mine in the United States—and, prior to the discovery of the New Caledonia deposits, one of the most important in the world—is that at Lancaster Gap. This mine was discovered, according to tradition, about the year 1718, and worked irregularly for copper until 1852, when it was found that the ore contained nickel. The Gap Mining Company, which owned the property, then commenced to operate it for nickel, and erected smelting-furnaces at the mines; but the undertaking was unsuccessful, and the mines and works were closed down in 1860, remaining idle until November, 1862, when they were purchased by Mr. Joseph Wharton of Philadelphia. Mr. Wharton reopened the mines in 1863, and at the same time established a nickel-refinery at Camden, N. J., which until recently was the only works of its kind in the United States.

The Lancaster Gap mine is opened in a deposit of nickeliferous pyrrhotite and chalcopyrite, the ore containing from one to three per cent nickel and a small amount of cobalt. The ore occurs in a contact vein between a schist formation and a huge, lenticular mass of hornblende rock. The vein is vertical, and from 4 ft. to 30 ft. in width, the mineral being mixed with a gangue of dark-colored, highly crystalline hornblende.*

Within the past few years the Lancaster Gap mine has been approaching exhaustion, and its output has been declining; for this reason the total production of nickel in the United States in 1892 was considerably less than that of the previous year. A shaft is now being sunk to determine if there are any workable deposits of ore at greater depths.

* For a further account of the history and geological features of this mine see *Report CCC of the Second Geological Survey of Pennsylvania.*

Canada.—The nickel and copper district of Sudbury, Ontario, now rivaling New Caledonia as the most important source of the world's supply of nickel, lies in the course of a belt of Huronian rocks, within which occur many inliers of gneiss and red quartz-syenite, the age of which is uncertain. The ore deposits of the region occur in both these formations. The ore consists in all cases of a mixture of chalcopyrite and nickeliferous pyrrhotite, the percentage of nickel in the latter ranging from one to three per cent. Specimens of millerite are found occasionally, and also the unique mineral sperrylite, arsenide of platinum. The area over which nickel has been found in this district extends from the Wallace mine on Lake Huron, in the vicinity of La Cloche, northeastward to the north side of Lake Wahnapitae, a distance of about 70 miles; and from the southeastern limit of the Huronian rocks of Sudbury northwestward to Geneva Lake, a distance of about 50 miles. The principal mines are controlled by the Canadian Copper Company, of Cleveland, Ohio; the Dominion Mineral Company, of Montreal, Canada; H. H. Vivian & Co., of Swansea; and the Drury Nickel Company, of Chicago, Ill. They were originally worked for copper, and it was not until a lot of ore had been shipped for smelting that its true character was discovered.

Mr. Henry W. Edwards-Vaughan writes as follows concerning developments in this district: "None of the mines have yet attained any considerable depth, the deepest being the Copper Cliff, which is down 600 ft. on a 40° slope. At this depth the ore shows no alteration in character, nor are there any signs that the bottom of the deposit is near. The ore delivered to the smelting furnaces throughout the district averages about two thirds the gross weight hoisted from the mines, one third being rejected by hand picking. After this sorting the ore averages from 1½% to 3% nickel, and from 1% to 4% copper. Coke is imported entirely from Pennsylvania, freight and duty amounting to about the same as the original cost of the coke."

Mr. A. Blue, Director of the Bureau of Mines of Ontario, furnishes the following report: "The Dominion Mineral Company was reconstructed during the year and did not begin operations until late in the season, its smelters being in blast only 67 days. The Drury Nickel Company did not complete its works until late in the summer, and its furnace was in blast for a limited time only. The total quantity of ore raised by the four companies was 72,349 tons, and the quantity smelted 61,924 tons. At three of the works a portion of the matte was bessemerized, and the total quantity of bessemerized matte was 1880 tons (of 2000 lbs.). The ordinary matte product of all the works was 6278 tons. The estimated quantity of nickel in the matte product was 2082 tons, valued at $590,902; of copper, 1936 tons, valued at $232,135; and of cobalt, 8½ tons, valued at $3713—the total value of the products being $826,750. The amount paid for wages of labor at the mines and works was $339,821."

New Caledonia.—Nickel was first discovered in New Caledonia in 1867 by M. Jules Garnier, but was not found in sufficient amount to be of commercial value until 1874. Nickel is now known to exist in all parts of the island except the northeastern point, which is of Silurian formation, the remainder of the area being made up of decomposed rocks of eruptive origin, among which serpentine is the most important. The nickel is found in the form of hydrous nickel-magnesium silicate (garnierite), deposited in concretionary masses in fissures in the serpentine

rock. This silicate is not a product of secondary decomposition, and the mode of occurrence indicates clearly that the mineral has been deposited by water in the form in which it is now found.* The distribution of the mineral through the serpentine matrix is not an arbitrary one, it being always found at or near the contact of the rock with the red clays, filling basins or cavities in the rock, but never in the clay itself. The clays are products of the decomposition of the serpentine, and are often covered by considerable deposits of oolitic brown iron ore, containing irregularly stratified masses of cobalt-manganese ore (2.5%-3% cobalt) and chrome iron ore, which latter mineral is also found in veins in the solid serpentine.

The nickel ore, which is of later origin than the cobalt and manganese, occurs as veins in crevices resulting from the shrinkage of the red clay from the sides of the rock-funnel inclosing it. These veins vary much in size, the maximum breadth being about 8 meters, but in some cases the whole of the rock is filled with small veins of mineral, so that it may be worked as a whole up to a thickness of 75 meters. Only the larger veins in the hard rock can be worked by underground mining; the walls are very irregular and may be easily lost, and by far the larger number of openings are open-cast. The nickel mines of New Caledonia are controlled by a French company, the Société de Nickel.

Norway and Sweden.—Nickel occurs in Norway at Ringerige, Tragerö, Moss, and Snarum; and in Sweden at St. Blasien, Klefra, and Sagmyra. At all these places the ore is a nickeliferous pyrrhotite, with from 0.5% to 2.5% nickel and a small amount of cobalt. These mines have been worked for many years, and at present stand third in the list of producers; their product, however, is far below that of either the New Caledonian or the Canadian mines.

Production.—The production of nickel in the United States in 1892 shows a further falling off, owing to the exhaustion of the Lancaster Gap mine. A small amount of nickel-bearing speiss was produced by the Mine La Motte, of Missouri. Some ore was taken out, in the course of development work, by the National Nickel Company and Geo. Lovelock, Sr., in Nevada, and some by the International Nickel Mining Company in Oregon; but no shipments were made from either of these places, and their products are not included in the total given in the following table.

PRODUCTION OF NICKEL IN THE UNITED STATES; ALSO IMPORTS AND EXPORTS.

Year.	Production.		Imports, Value.	Exports, Value.	Year.	Production.		Imports, Value.	Exports, Value.
	Amount, lbs.	Value.				Amount, lbs.	Value.		
1876	201.367	$523,554	$ 10	$203,150	1885	277.904	$179,975	$64,166	$11,773
1877	188,211	301,138	10,346	8,200	1886	214,992	127,157	141.546	51,353
1878	150,890	165.979	16,684	2,452	1887	205,566	133,200	205,232	46,709
1879	145.120	162,534	13,399	.....	1888	204,328	127.632	138.290	39,576
1880	233,893	257,282	66,069	4,120	1889	217.663	130,598	156,331	100
1881	265,668	292,235	122,130	39.480	1890	200,332	130,216	376,279	471
1882	281.616	309,777	143,660	19,674	1891	120,848	72,509	345,286	184,728
1883	58,800	52,920	132,484	22,093	1892	96,152	57,691	†165,149	†186,302
1884	64.550	48.412	129,733	22,429	....	....	....	....	... .

NOTE.—The values of the imports of nickel given in the above table include the value of nickel brought into the country in the form of oxide and alloyed with copper, besides that of the refined metal. The values of the

* D. Levat, formerly director-general of the Société de Nickel, in *Annales des Mines*, 1892, vol. i. p. 141.

† Six months.

exports are those of refined metal, ore and coin, all of domestic production. Both imports and exports are stated for calendar years since Dec. 31, 1886, previous years ending June 30.

The figures of production from 1876 to 1888, both years inclusive, are taken from the *Mineral Resources of the United States*, 1889 and 1890; the figures for 1889 are those compiled by the Eleventh Census, while those for 1890, 1891, and 1892 have been collected by the author. The figures for 1889 and 1890, given in the *Mineral Resources of the United States*, vol. vii., represent the products of the various nickel works of this country, making no distinction as to whether the metal was derived from domestic or imported ores. It is not clear whether the statistics for 1888 and previous years are collected in the same manner, but in any case the amount of nickel produced from foreign ores before 1889 (when the Canadian mines began to yield) by American refining works was insignificant. The amount of metal thus turned out in 1889 is stated by the Census Report to have been 35,000 lbs. The statistics for 1890, 1891, and 1892, in the above table, give the product of the United States only.

The exports of nickel ore from New Caledonia for the past eight years have been as follows: 1884, 10,888 metric tons; 1885, 5,228; 1886, 920; 1887, 8,602; 1888, 6,616; 1889, 19,741; 1890, 22,690; 1891, 35,000. These figures are taken from an abstract of *L'Annuaire de la Nouvelle Calédonie pour* 1891, in a recent number of *L'Echo des Mines et de la Métallurgie.* The exports for 1892 have probably exceeded those of 1891. The New Caledonia nickel ore, which is shipped to the smelting works at Glasgow, Scotland, averages about 10% nickel at the present time.

The nickel-copper matte smelted in Canada in 1890 contained 1,435,742 lbs. of nickel. In 1891 there was an immense increase in production, the amount of nickel turned out in matte being stated officially as 4,626,627 lbs.; the product in 1892 is returned at 4,164,000 lbs. The output of nickel in Norway in 1889 was 149,872 lbs., against 145,464 lbs. in 1888; the product for 1890 is estimated at 145,000 lbs. Sweden produced 17,742 lbs. in 1890, against 90,350 lbs. in 1889. The production of Prussia and other countries is insignificant. The total annual nickel supply of the world (in pounds) may be approximated, therefore, as follows, estimating the figures for New Caledonia at 7% of the exports of ore:

Country.	1889.	1890.	1891.
Canada	682,773	1,435,742	4,626,627
New Caledonia	3,045,641	3,500,613	5,399,800
Norway and Sweden	240,222	162,742	160,000*
United States	217,633	200,332	120,848
Total	4,186,269	5,299,429	10,307,275

* Estimated.

Metallurgy.—The new Mond process for the reduction of nickel ores * has not yet been introduced on a working scale, but a small plant has been constructed in Mr. Mond's laboratory, by which a variety of ores have been tested, and a large plant is now being erected at Birmingham, England.

During the past year new nickel-refining works have been erected by the Emmens Metal Company at Youngwood, Penn., while the works of the Canadian Copper Company, near Cleveland, Ohio, have been completed and put in operation.

Composition.—The composition of commercial nickel, nickel matte, nickel oxide, etc., is shown by the following table from an article by Mr. S. H. Emmens in the *Engineering and Mining Journal*, Nov. 26, 1892:

* A full description of this process may be found in the *Engineering and Mining Journal*, Sept. 26, 1891.

Substance.	Date.	Percentage Composition.						
		Ni.	Co.	Ni + Co.	Fe.	Cu.	S.	C, SiO_2, and other Impurities.
Matte (Swedish) (*a*)	......	....	....	26.00	16.33	31.67	26.00	.... (1)
Do. (Sudbury) (*b*)	1889	14.84	.27	14.71	31.00	27.06	26.90	.92
Do. (do.) (*b*)	1889	13.04	.20	14.04	31.47	26.76	27.00	.95
Bessemerized (do.) (*c*)	1892	....	....	35.93	1.09	40.98	19.71	2.29 (2)
Do. (New Caledonia) (*d*)	......	....	....	67.17	11.90	....	17.08	3.85
"Fonte" (do.) (*d*)	......	....	....	67.95	25.87	....	1.95	2.90
Nickel oxide (Sudbury) (*e*)	1891	....	....	74.60	1.51	1.25	....	1.45
Do. (New Caledonia) (*f*)	1891	....	....	77.92	.25	.09	....	....
Artificial nickel ore (*g*)	1891	....	....	48.23	23.87	trace	.264	27.636
Nickel (German) (*h*)	......	56.75	....	56.75	12.55	27.50	....	3.70
Do. (do.) (*h*)	......	54.60	....	54.60	11.30	30.10	....	4.00
Do. (English) (*h*)	......	73.30	22.10	95.40	1.00	trace	....	3.00
Do. (New Caledonia) (*i*)	1881	....	....	97.75	(Mn) .36	....	....	1.79
Disk nickel (New Cal.) (*d*)	......	....	....	98.83	.72	....	....	.45
Cast nickel (*j*)	......	97.44	trace	97.44	.301	....	.104	2.155
Sheet nickel (German) (*k*)	1891	97.05	1.858	98.908	.829	.498	.012	.042 (3)
Rolled anode (German) (*k*)	1891	97.63	1.19	98.82	.75	.15	.04	.24 (4)
Disk nickel (*k*)	1891	97.38	1.70	99.08	.06	.68	.013	.167 (5)
Cube nickel (*k*)	1891	96.757	1.586	98.343	.32	.113	trace	1.224
Grain nickel (*k*)	1891	94.988	.856	95.844	.354	.047	trace	3.755 (6)
Do. do. (*k*)	1892	96.29	.93	97.22	1.92	.20	.104	.556 (7)
Cast nickel anode (*k*)	1892	83.68	trace	83.68	7.10	.15	.19	8.88 (8)
Do. do. do. (*k*)	1891	82.776	1.133	83.909	12.091	.103	.05	3.847 (9)

(*a*) Analysis from Wagner's *Chem. Tech.*, 8th ed. (*b*) Canadian Copper Co., F. L. Sperry, analyst. (*c*) Canadian Copper Co. (*d*) Analysis from Thorpe's *Dict. of Applied Chem.* (*e*) Orford Copper Co., Hunt & Clapp, analysts. (*f*) Société de Nickel, Ledoux, analyst. (*g*) E. F. Wood, analyst. (*h*) Lassaigne (Watts' *Dict.*), analyst. (*i*) Christofle and Bouilhet, analysts. (*j*) Gard (Wagner, 13th ed.), analyst. (*k*) F. P. Dewey, analyst.

(1) and (2) Average of three assays.

(3) "It showed by qualitative analysis slight traces of arsenic, antimony, and aluminum, and a perceptible amount of silicon. No other metal or phosphorus was found."—*Note by Mr. Dewey.*

(4) "Showed some silicious residue."—*Note by Mr. Dewey.*

(5) "A small amount of hard, gritty grains left on dissolving the metal."—*Note by Mr. Dewey.*

(6) "It showed by qualitative examination the slightest traces of arsenic and antimony, some aluminum, and considerable silicon and calcium. Distinct grains of slag were found. No other metal or phosphorus was found."—*Note by Mr. Dewey.*

(7) "There is some Si and considerable As in this sample."—*Note by Mr. Dewey.*

(8) "It contained a considerable amount of tin, probably 7%. There is also considerable silicon present."—*Note by Mr. Dewey.*

(9) "It showed on qualitative analysis slight traces of arsenic and antimony, some aluminum and calcium and considerable silicon. No other metal or phosphorus was found."—*Note by Mr. Dewey.*

Uses.—The great increase in the demand for nickel during the past two years has been due to the large purchases of the United States Government for the manufacture of nickel-steel armor plate, the reported decision of the French Government to plate certain parts of its military rifles with nickel, and the large contract given by the Austrian Government for nickel for coinage.

Another new channel of consumption—and an important one—is the manufacture of a nickel-copper alloy (Ni. 20%, Cu. 80%) for casing bullets to be used with small-bore rifles now adopted by all the armies of Europe. This alloy has a higher degree of tenacity than the best brass, combined with a high co-efficient of elongation. At the same time there has been the natural increase in the demand for nickel for use in the arts.

In this connection it should be noted that American nickel-steel armor-plates have recently been tested by the Russian Government at its proving-ground at Ochta, near St. Petersburg, with very satisfactory results; and from the last report of the Chief of Engineers of the United States Navy it is probable that experiments will be made this year to determine the utility of nickel-steel in the construction of propeller-shafts and certain parts of the engines for the new men-of-war that are now being built.

Price.—It is difficult to recount all the fluctuations in price of nickel during the past year owing to the manner in which most of it is sold, i.e., by long contracts—three, six, or twelve months. The number of refiners is limited; some buyers favor one brand of metal and others another, so that prices are more or less dependent upon the whims of consumers. Weekly quotations, therefore, represent only the price brought by small lots, which form but a small proportion of the total transactions. The contracts closed early in 1892 were made at prices ranging from 55c. to 60c. per lb., these quotations being for metal 98% to 99% fine. Lately a very good nickel of the same fineness has been offered at 52c. to 54c., and at the close of the year could be bought at 50c.

Cobalt.

A small amount of cobalt oxide is recovered annually as a by-product in the reduction of nickel ores.

UNITED STATES: PRODUCTION AND IMPORTS OF COBALT OXIDE.

Year.*	Production.	Imports.		Year.*	Production.	Imports.	
	Pounds.	Pounds.	Value.		Pounds.	Pounds.	Value.
1869	811	....	2,330	1881	8,280	21,844	13,837
1870	3,854	....	5,019	1882	11,653	17,758	12,764
1871	5,086	....	2,766	1883	1,096	13,067	22,323
1872	5,749	....	1,920	1884	2,000	25,963	43,611
1873	5,128	1,480	4,714	1885	8,423	16,162	28,138
1874	4,145	1,404	5,500	1886	8,689	19,366	29,543
1875	3,441	678	2,604	1887	5,769	26,882	39,396
1876	5,162	4,440	11,180	1888	7,491	27,446	46,211
1877	7,328	19,752	11,056	1889	12,955	41,455	82,322
1878	4,508	2,860	8,693	1890	6,788	33,338	63,202
1879	4,376	7,531	15,208	1891	7,200	35,483	60,630
1880	7,251	9,819	18,457	1892	8,600	†17,168	†31,860

* Production is stated for calendar years; imports for fiscal years ending June 30 until 1887 and calendar years subsequently. † Six months.

The following paragraphs, describing the manufacture of cobalt at the Maletra Works, Rouen, France, are abstracted from an article in the *United States Consular Reports*, September, 1891:

"The ore which is mined in New Caledonia is, approximately, of the following composition: Peroxide of manganese, 18%; peroxide of cobalt, 3%; protoxide of nickel, 1.25%; silica, 8%; ferric oxide, 30%; alumina, 5%; lime, 1%; magnesia, 1%; moisture, 32.75%—total, 100%. The process used by the Maletra Company for the extraction of the cobalt in this ore is a new and ingenious one, devised by the metallurgists of the company.

"The mineral in a state of powder is thrown into large vats filled with a solution of protosulphate of iron and thoroughly mixed by a jet of steam. The manganese, the cobalt, and the nickel are taken up by the liquid in the form of sulphates. The iron that is in the mineral, as well as that in the solution, is precipitated in the form of peroxide and partly as persulphate, with the alumina and silica. The liquid (containing in solution the manganese, cobalt, and nickel) is drawn off, and the residue (containing iron and alumina) is passed through a filter-press, and after calcination may be used as colcothar. The protosulphate of iron used in this operation is made in the establishment by attacking scrap-iron with one of the residues rich in sulphuric acid known as bisulphate of soda. This bisulphate of soda forms, with the scrap-iron, protosulphate of iron and also sulphate of soda, used subsequently. The sulphate of soda is separated by

crystallization. The liquid containing the manganese, cobalt, and nickel is run into stone basins, to which is added sulphide of sodium, which precipitates the whole of the cobalt and nickel, but leaves the greater part of the manganese in solution. The sulphide of sodium is produced in a corner of the establishment by boiling in a closed vessel one of the by-products—black-ash waste from the carbonate of soda furnaces—and the sulphate of soda residue from the making of the protosulphate of iron already described.

"The precipitate containing the cobalt, nickel, and a small quantity of manganese is washed, passed through the filter-press, and then treated with perchloride of iron (produced in one of the succeeding operations), which dissolves the manganese. This second operation gives (1) a black precipitate of comparatively pure sulphides of cobalt and nickel and (2) a liquid containing sulphate and chloride of manganese. To the liquid is added chloride of lime, obtained in one of the subsequent operations, and the manganese precipitated by the lime becomes a by-product which is used in the Weldon process.

The third operation consists of drying the sulphides of cobalt and nickel and then carefully roasting them in a reverberatory furnace, when, if carefully done the sulphides of the two metals become soluble sulphates.

"The fourth operation is the most difficult. The soluble sulphates are washed with boiling water. The solution is treated with chloride of calcium. Of the solution (a) containing chloride of cobalt and nickel a certain quantity is taken, and the cobalt and nickel are precipitated by lime. This precipitate of oxide of nickel and cobalt is washed to remove any chloride of calcium that might remain, then placed in a suitable vessel, a sufficient quantity of water added, and submitted to a current of chlorine gas and air under pressure to produce a thorough mixing. To the peroxides so obtained is added a new portion (b) of the liquid a, and the two being mixed up thoroughly by a jet of steam, a curious change takes place. The peroxide of nickel, changing into protoxide, enters into solution and is displaced continuously by an equivalent proportion of cobalt from the first solution. The liquid then contains chloride of nickel, the cobalt being precipitated as peroxide of cobalt. The second portion (b) is calculated so as not to displace the whole of the nickel. This liquid is now run off and a fresh quantity of a added; and so on until on testing it is found that the precipitate contains nothing but peroxide of cobalt, when the operation is finished. The solutions containing nickel are treated with lime, and the nickel precipitated as oxide. The products of the operation are (1) protoxide of nickel, (2) peroxide of cobalt, (3) chloride of calcium. The chloride of calcium is required in one of the preceding operations. The separated oxides of nickel and cobalt are filter-pressed, dried, and calcined."

The Maletra Company treats at present about 150 tons of ore per month, containing 3% cobalt and 1¼% nickel. The total exports of cobalt ore from New Caledonia from 1875 to 1892 have been 24,938 metric tons. During the past few years the exports have ranged from 2500 to 4000 tons per annum.

The total production of cobalt in the world is about 200 tons per annum. Its principal use is in the manufacture of a pigment, an intense and unchangeable blue, which is largely applied in tinting porcelain.

THE METALLURGY OF NICKEL.

BY STEPHEN H. EMMENS.

The number of minerals at present known to be nickeliferous is 105, but of these very few are of industrial importance. It may indeed be said with practical accuracy that the world's production of nickel is derived from only two sources, viz., the nickel-magnesium silicate (garnierite) of New Caledonia and the nickeliferous pyrrhotite of Canada. The composition of these ores is shown in the following summary from published analyses: GARNIERITE.—Nickel, 0.24% to 35.48%; magnesia, 2.47% to 37.38%; silica, 35.45% to 66.97%; alumina and iron oxide, 0.11% to 15.13%; lime, *nil* to 1.90%; sulphuric anhydride, *nil* to .83%; water, 5.27% to 17.75%. PYRRHOTITE.—Nickel, *traces* to 11.17%; cobalt, *traces* to 1.02%; iron, 49.97% to 61.84%; copper, *traces* to 0.54%; sulphur, 36.35% to 43.63%; magnesia, *nil* to 0.96%; arsenic, *nil* to 0.04%; gold, platinum, and silver, *traces*.

Inasmuch, however, as ore containing manganese and cobalt is found in the vicinity of the New Caledonian nickel deposits, the garnierite imported into Europe is seldom free from those metals; and as chalcopyrite is an almost invariable associate of the Canadian pyrrhotite, the percentage of copper is higher than that shown in the analysis The pyrrhotite, moreover, is usually accompanied by a considerable quantity of intimately admixed gangue of a dioritic or diabasic character. Hence the proportion of nickel in the pyrrhotite as mined becomes much reduced, and seldom amounts to more than three per cent.

Treatment of Garnierite.—The ore is smelted in a low-blast furnace with coke and gypsum, alkali-waste or salt-cake, so as to remove the silica, magnesia, etc., in the form of slag, and produce a regulus of nickel and iron. This regulus is then subjected, in a reverberatory furnace, to a series of alternate roastings and fusions with sand, whereby the iron is gradually slagged off and almost pure nickel sulphide finally obtained, which may be converted into oxide by calcination. Bessemerization is sometimes resorted to as a substitute for the first roasting and fusion of the cupola matte.

Treatment of Pyrrhotite.—The ore is stacked in roast-heaps containing some hundreds of tons, and ignited by means of cordwood beneath the heap. The burning continues for several weeks, and results in the removal of much of the sulphur and a partial oxidation of the iron. The roasted ore is then smelted with coke in a low-blast furnace, the gangue serving as a sufficient flux, the product being a regulus of nickel, iron, and copper. This regulus is then bessemerized in converters lined with silica, which substance unites with the oxidized iron to form a slag, while the copper and nickel remain as sulphides. The enriched matte is next calcined in a reverberatory furnace to remove most of the sulphur, afterward roasted with salt, and the copper chloride removed by lixiviation. If any considerable amount of iron remains with the nickel, the lixiviated material is dried, mixed with a little pyrite (or other sulphur compound) and sand, and fused in a reverberatory furnace so as to slag off the iron and leave almost pure nickel sulphide, which is then converted into oxide by calcination.

Reduction of the Nickel Oxide.—The oxide obtained as above described is, if pure, intimately mixed with charcoal and heated to whiteness in graphite cruci-

bles, where it assumes the metallic condition, and when molten is granulated by being poured into water. Some manufacturers, however, mix the oxide either with finely powdered wood charcoal or with flour or starch made plastic with molasses, and mold the mixture into cubes, disks, or coarse grains, which are then packed in crucibles with charcoal and exposed to a heat short of that required for fusion. The metal is thus reduced, and remains, as coherent, close-grained masses, in the disk or other shape selected.

Cost of Production.—In the *Report of the Ontario Bureau of Mines for* 1891 it is stated that "the product of eight nickel mines operated by four mining companies was 85,790 tons," and "the total amount paid for labor (not including roasting or smelting) was $322,201." If to this there be added an allowance for fuel, timber, repairs, etc., the cost per ton of pyrrhotite delivered at the breaker cannot safely be estimated at less than $5 per ton; although it is customary, in the prospectuses of Canadian mining companies, to see it reckoned as $2 per ton. In the case of garnierite no statistics are available; but in view of the New Caledonian mines being situated high up in the mountains, at a distance from the coast, and taking into consideration the inefficient character of the labor employed and the expenses of freightage to Europe, it may be assumed that the total cost of the ore delivered at the Scotch or French reduction works is not less than $20 per ton. As, however, it contains an average of 10% of nickel, whereas the pyrrhotite averages 2.62% (*vide* the Report before mentioned, p. 90), the prime cost of the raw material for treatment—that is to say, the nickel in the state of ore—is about the same in both cases, namely, 10c. per lb.

The costs of succeeding operations are as follows: Breaking, $0.30 per ton; heap-roasting, $0.50; cupola-smelting, $2.50; bessemerizing, $2; reverberatory-calcining, $1.25; reverberatory-fusion, $3.54; refined-sulphide roasting, $5; chlorination and lixiviation, $4. Accordingly, the total cost of one ton of nickel oxide, containing, say, 76% of metallic nickel, may be thus estimated: I. *From Garnierite.*—Smelting for matte, 7.6 tons at $2.50, $19; first calcination, 2.0 tons at $1.25, $2.50; first fusion, 2.0 tons at $3.54, $7.08; second calcination,* 1.75 tons at $1.25, $2.19; second fusion, 1.75 tons at $3.54, $6.20; pulverization of refined sulphide, $0.50; first roast of refined sulphide, $5; second pulverization, $0.50; second roast, $5—total, $47.97. II. *From Pyrrhotite.*—Breaking 29 tons at $0.30, $8.70; heap-roasting, 29 tons at $0.50, $14.50; smelting for matte, 30 tons at $2.50, $75; bessemerizing, 5 tons at $2, $10; first calcination, 2.50 tons at $1.25, $3.15; chlorination and lixiviation, 2.50 tons at $4, $10; second calcination, 1.75 tons at $1.25, $2.19; second fusion, 1.75 tons at $3.54, $6.20; pulverization of refined sulphide, $0.50; first roast of sulphide, $5; second pulverization, $0.50; second roast, $5—total, $140.74.

If the oxide be sufficiently pure to require no intermediate refining, and if it be run direct into granulated metal by reduction in crucibles, the cost incurred for crucibles, fuel, charcoal, labor, repairs, etc., is about 8c. per lb. of nickel produced. Hence the ultimate cost of the metal is as follows: *Garnierite.*—Mining and transport, 10c.; conversion into oxide, 3c.; reduction into metal, 8c.; allowance for loss in working, 1c.—total, 22c. *Pyrrhotite.*—Mining and transport, 10c.;

* The number of calcinations and fusions at this stage sometimes amount to five.

conversion into oxide, 9c.; reduction into metal, 8c.; allowance for loss in working, 4c.—total, 31c.

In considering the foregoing figures it must be remembered that they are based upon the supposition that the work is carried on upon a large scale and in a locality where labor and fuel are cheap. They also assume that the ores treated are free from any appreciable quantity of arsenic or other impurity. It will be obvious, therefore, that the expectation at one time entertained of the market price of nickel being reduced to 30c. per lb. is not likely to be realized very soon.

It must also be borne in mind that the cheapening of production brought about by the development of the modern "dry" processes of reduction above described, in the place of the "wet" methods formerly employed, has of late been more than offset by the demand for extreme purity of the metallic product. This feature of the market confers a very great additional advantage upon the New Caledonian as compared with the Canadian ores, and tends to an enhancement of price. In illustration of this I may mention that in December, 1892, 70c. per lb. was asked by the leading nickel-refiner in the United States for metal of first-class quality; whereas the price asked for the regular grade (98% pure), prepared from the same ore, was 56c.

Space does not admit of my describing the treatment of the arsenical ores of nickel which previous to the discovery of the New Caledonia deposits formed the chief source of the world's supply. These ores have now become unimportant. If, however, any person desires information on the subject, he may readily obtain the same by referring to any of the text-books, among which the *Introduction to the Study of Metallurgy*, by Prof. W. C. Roberts-Austen, F.R.S., is to be particularly recommended.

The coming year will probably witness the practical introduction of some modified methods of treatment of nickeliferous pyrrhotite, having for their aim the relegation of the cumbrous, expensive, and nuisance-breeding roast-heaps and smelters to the background of a noisome past. These methods are four in number, and may be briefly described as follows:

1. *The Mond Process.*—Mr. Ludwig Mond, F.R.S., has discovered that carbonic oxide (CO) if brought into contact with finely-divided nickel at a temperature below 150° C. will form a readily volatilized compound, each molecule of which consists of one molecule of nickel and four molecules of carbonic oxide. This "nickel-carbon-oxide" (NiC_4O_4) is a colorless liquid which boils at 43° C., and its vapor when heated to about 180° C. becomes decomposed into metallic nickel and carbonic oxide. Mr. Mond, therefore, proposes to treat pyrrhotite by first pulverizing and dead-roasting it to a condition of complete oxidation; then reducing it to a finely divided metallic state by subjecting it to the action of hydrogen or some other reducing gas, at a temperature of from 350° to 400° C.; then subjecting this finely divided metal, at a temperature of about 50° C., to the action of a current of carbonic oxide which carries off the nickel in the form of vaporized NiC_4O_4 and leaves all other metals behind; and, finally, passing the vapor through tubes or vessels heated to about 180° C., where "the nickel separates out in coherent metallic masses of great purity." If this process proves practicable on a large scale it should supersede all others. But some doubts may be permitted. In the first place, it is known that iron also forms a volatile com-

pound with carbonic oxide, and therefore the Mond nickel may contain too much iron to compete with the highly purified market grades. In the second place, the finely divided metallic powder soon becomes inert in the presence of carbonic oxide, and requires revivifying by being "heated up to 300° to 400° C. in a current of carbonic oxide or hydrogen, and cooled down again to ordinary temperature, by which means its energy is restored." In the third place, the formation of NiC_4O_4 requires 24.34 cubic ft. of CO for every pound of nickel vaporized (= 1.51943 liters per gram); and as in practice only a small proportion of a flowing current of gas can be made to come into contact with a powdered material, it follows that each pound of nickel will require the flow of many times 24.34 cubic ft. of carbonic oxide "free from oxygen or halogens." Mr. Mond, however, and his colleague, Mr. Quincke, are not men to be easily baffled by any difficulties of operation, and it is to be expected that the Mond nickel will soon enter the market.

2. *The Gossan Process.*—I have discovered that the nickel in pyrrhotite is easily dissolved by a solution of ferric sulphate, the reagent employed by Nature in her gossan-forming attack upon the outcroppings of metallic veins. This reaction will take place even if the ore be in a raw state, but it is greatly accelerated by a preliminary low-roast. I therefore propose to replace the ordinary roast-heaps and smelters by weathering-floors, a low-roasting furnace, and lixiviation tanks; the product being obtained and shipped to the refineries in the shape of either crystallized nickel sulphate or precipitated nickel hydrate. The simplicity, economy, and high concentration power of this process are obvious.

3. *The Macfarlane Process.*—This is an application of the well-known Henderson chlorination method of treating calcined cupriferous pyrites. Mr. Macfarlane proposes to treat the nickeliferous pyrrhotite as follows: (*a*) Roast in order to burn off the greater part of the sulphur. (*b*) Mix the roasted ore with about one eighth its weight of common salt (sodium chloride) and reduce the mixture to powder. (*c*) Calcine the mixture at a low-red heat. (*d*) Lixiviate with hot water. (*e*) Add a small quantity of caustic soda to precipitate any iron in the solution. (*f*) Add sodium sulphide to precipitate any copper present. (*g*) Add caustic soda to precipitate the nickel as hydrate.

4. *The McTighe-Edison Process.*—On Dec. 9, 1890, Mr. T. J. McTighe, the well-known electrical engineer, submitted a quantity of powdered nickeliferous pyrrhotite from the Loughrin mine, in the Algoma district of Ontario, to the action of a Ball electro-magnetic separator, and found that by this method the raw ore could be separated into three qualities, viz., fully magnetic, feebly magnetic, and non-magnetic, with a corresponding concentration of the nickel contents. On July 20, 1892, Mr. T. A. Edison filed an application in the United States Patent Office, and this resulted in the grant to him on Nov. 8, 1892, of United States Patent No. 485,842 for an invention which (apart from all question of priority between Mr. McTighe and Mr. Edison) is of considerable scientific and industrial importance. I therefore deem it desirable to quote the main portion of the specification, which is as follows:

"I have discovered that where magnetic pyrites, called 'pyrrhotite,' is nickeliferous, as it usually is to a more or less extent, the nickle is not distributed generally throughout the whole body of the pyrrhotite, but certain crystals are pure pyrrhotite or magnetic pyrites, while other crystals have some of the iron replaced

by nickel and sometimes by cobalt, and that the crystals containing the nickel or cobalt are considerably less magnetic than the pure pyrrhotite.

"In carrying out my invention I proceed as follows: Assuming the ore to contain nickeliferous pyrrhotite or magnetic pyrites, chalcopyrite, or copper pyrites, with gold, etc., I first grind the whole of the crude ore, so as to eliminate the pyrrhotite, gold, etc., from the worthless gangue. The crushed ore is then concentrated by jigging or vanning or by any other appropriate concentrating method, thus giving a concentrate containing the nickeliferous pyrrhotite, gold, blende, and galena without any material quantity of quartz or other worthless matter. This concentrate is then passed through a magnetic separator which is capable of working wet ores, or the concentrate is dried and passed through a magnetic separator adapted to work dry ores. The magnetism is so regulated that only the particles of magnetic pyrites which contain no nickel or cobalt are acted upon, the magnetism being too weak to draw away the less magnetic or nickeliferous pyrrhotite. After the pure pyrrhotite has thus been separated the remainder of the concentrate is run through a more powerful magnetic separator, which withdraws the nickeliferous pyrrhotite, leaving all the other or non-magnetic materials. The nickeliferous pyrrhotite which is obtained in this way, although small in quantity compared with the whole amount of ore, will be sufficiently rich to be put into a matte by the regular methods. The remainder of the concentrate is then roasted in a closed cylinder with slight access of air, if desirable, to render the copper pyrites magnetic, when the magnetic copper pyrites may be withdrawn from the rest of the material by a magnetic separator, as explained in my patent, No. 465,250. After the copper pyrites have been withdrawn from the concentrate the remainder, containing the gold, silver, zinc, lead, etc., of the original ore, is worked in the wet way, or matted and worked electrolytically, as will be well understood."

Mr. McTighe's method of working differs from that of Mr. Edison and is more efficient; but as his patents have not yet been issued, I am not at liberty to enter into details. It will be sufficient to say that the process of magnetic separation, in both the McTighe and the Edison form, is likely to be adopted in many localities, even though Mr. Edison's theory of the nickel occurring as an element replacing some of the iron in what otherwise would be "pure pyrrhotite" is not in accordance with the chemical facts of the case.

The Orford Nickel Process.

By Robert M. Thompson.

Since the first of 1891 the Orford Copper Company has been the largest refiner of nickel-copper matte in the United States, employing a new process, invented by its metallurgists, which is a notable improvement in the metallurgy of nickel. The history of this process is as follows:

Three years ago the Navy Department applied to the Orford Copper Company to treat a quantity of Sudbury matte, and to supply a nickel oxide to be used in making nickel-steel for armor-plates. The first process employed was the use of dilute sulphuric acid on the raw or uncalcined matte, thus dissolving out the nickel and iron sulphides, and leaving the copper behind. The nickel and iron were then crystallized from the solution as sulphates, and these sulphates were calcined, producing an oxide of nickel and iron quite free from copper. The objection to this process was the very large plant required, its slowness, and the difficulty of making a complete separation of the matte, as a large portion of the nickel was always left behind, and the matte soon got into such condition that the operation could not be continued.

As the Orford Copper Company had contracted to treat a very large quantity of matte it was felt that some cheaper and more expeditious process must be devised, and a number of experiments were conducted by the superintendent of its works, Mr. John L. Thomson, and his assistant, Mr. Charles Bartlett.

Mr. Bartlett observed that on melting the mattes in a crucible with salt cake the metals tended to separate, the greater portion of the nickel being found in the bottoms, and the greater portion of the iron and copper in the tops, there being a distinct line of separation between the tops and bottoms. Upon this indication the question was taken up, and many experiments were conducted on a working scale. The difficulty always seemed to be that no complete separation was attained, but they tried experiment after experiment, and having calculated what results should be attained, they were never satisfied until these results were arrived at. One disturbing cause after another was ferreted out and removed, until at last they are producing a nickel oxide assaying as follows: Nickel, 77.62%; copper, 0.161%; iron, 0.637%; silica, 0.32%; sulphur, 0.025%; arsenic, 0.047%.

The process, in brief, is this: The metals in the matte are reduced by a preliminary treatment, either by the Bessemer process or by ordinary calcining and melting in a blast-furnace, to a point where the metals are present substantially as sub-sulphides. This matte is then melted with an alkaline sulphide (in practice with salt-cake, i.e., sulphate of soda, which in the blast-furnace is reduced to sulphide of soda), and a reaction follows in which the copper and iron take the sulphur from the soda. By adding the proper proportion of salt-cake the bulk of the iron and copper are converted into sulphides, and, mixing with the soda, make a very fluid mass from which the subsulphide of nickel separates by gravity and on cooling leaves in the tops the bulk of the copper and iron and the soda, and in the bottoms the bulk of the nickel. On exposure to the weather the soda in the tops is converted into caustic soda; mixing these tops with matte and remelting, the caustic soda is converted into sulphide of soda at the expense of

the nickel, leaving the latter in a semi-metallic state, and again a top and bottom is formed with copper and iron in the top and nickel in the bottom. By properly balancing these various treatments a pure sulphide of nickel is at last obtained, which by calcining is converted into an oxide.

It is due to Mr. Thomson and Mr. Bartlett to state that there has been no metallurgical work in the last decade carried out more thoroughly or scientifically than the working out of this process. Time after time it seemed as if the process must be abandoned, but Mr. Thomson's scientific scent always brought him back to the right path, and the indefatigable practical work of Mr. Bartlett made a combination which it was impossible to defeat.

The metallurgical world at large must benefit greatly from the cheapening of nickel which this process will give, and I may add that a further extension of the process is being perfected which has already in a laboratory way given metallic nickel of 99.9% purity, and when this shall be put on a working scale it seems as if very little will remain to be done in the metallurgy of nickel.

PRODUCTION OF NICKEL BY THE ORFORD COPPER COMPANY.

Year.	Receipts of Matte.		Receipts of Ore.		Fine Nickel in Oxide produced.		Fine Nickel in Oxide furnished U. S. Government.	
	Tons of 2240 lbs.	Nickel Contents, Pounds.	Tons of 2240 lbs.	Nickel Contents, Pounds.	Pounds.	Value.	Pounds.	Value.
1891....	6,123	2,230,654	20	2,967	855,970	$299,589.50	254,418	$89,046.30
1892....	2,081	1,204,084	116	8,577	2,059,697	720,893.95	747,329	261,565.15

ONYX.

Onyx is found in several localities in the United States, but quarries of importance have been opened in Arizona alone. Most of the stone used in this country is imported from Mexico, where quarries at a number of places are being worked by American capital. The quarries at Big Bug, Ariz., were thus described by Mr. John F. Blandy, M.E., in the *Engineering and Mining Journal* of March 26, 1892:

"The deposit on Big Bug Creek, about 30 miles southeast of Prescott, was located in 1890; since that time the beds have been opened at many places, and much of the stone has been sent to various points east and west for the purpose of introducing it into the market. The quarries are 30 miles from the Prescott and Arizona Central Railroad, but as there is a good wagon road it can be hauled on the cars at a cost of $7.50 per ton. The stone weighs about 200 lbs. per cubic ft., or 10 cubic ft. to the ton.

"The beds of onyx are exposed for a distance of about 2,000 ft. in a bluff, which forms the east bank of the creek, and extends to the north and east over an area of about 200 acres. The section of the bluff shows a base of breccia, or natural concrete, of unknown depth (not less than 50 ft.), which extends out under the creek. The top of this deposit is plainly marked in the bluff at the height of 15 to 20 ft. above the water. Upon it lies the first strata of onyx, 12 ft. thick, made up of layers from 6 in. to 2 ft. in thickness. Upon this lies a second bed of breccia, 5 ft. thick, and next in super-position a 5-ft. bed of onyx, reaching to the crown of the bluff. This exposed section cannot be considered as a type of the whole deposit, since the force which brought down the material of the breccia, varying in size from a pea to a paving stone, was a violent one, and would necessarily scatter the material very irregularly, whereas the materials of the onyx were precipitated in still waters. Judging from the limited explorations in depth which have been made, it would seem that the center of the basin was some 1500 ft. to the northeast of the bluff, as at that part of the field no exposures of breccia have been found, and further, the deposit of onyx shows much greater thickness than is shown in the bluff. The finding of large fragments of onyx at points from a mile to a mile and a half farther up the creek would indicate that a large area has been entirely denuded.

"The boulders and gravel of the breccia are fragments of the rocks of the surrounding country, granites, syenites, and crystalline schists, firmly cemented together by lime, etc. Some of the onyx layers carry an appreciable amount of silica, but no analysis has, to my knowledge, been made of the rock.

"The large areas of lava existing on the hills to the west and north of the onyx field are no doubt the source whence came the lime-bearing waters. All these lava beds throughout the country are underlaid by heavy beds of tufa, or volcanic ash, the springs from which have made deposits of various character. The so-called verde salt (principally sulphate of soda) has no doubt been formed in this way, and in the Eureka mining district are fine deposits of travertine limestone, rich in fossils. In both of these cases the scoria beds are visible in the bluffs above the deposits.

"The stone from the Big Bug quarries compares well with the Mexican onyx, both in fineness of grain and in beauty. Of course this cannot be said of all the layers, nor has sufficient work been done to decide which are the finest layers. In richness and variety of colors nothing better can be desired than the stone found in Arizona. The colors are various shades of red, pink, brown, yellow, and green, the latter predominating. The darker shades exist in thin, waving bands from an eighth of an inch to an inch in thickness, and when the stone is sawn nearly parallel with the bedding it presents a face of surpassing beauty. Blocks of any desirable size, even up to 20 ft. in length and 6 to 10 ft. in width, can be obtained.

"As very little stripping has to be done, and the strata lie nearly horizontal, the cost of quarrying will be low. A line of railroad is now being surveyed from Phœnix to Prescott, which will pass near the quarries, and will no doubt be built to that point within the year. This will afford direct transportation either northward to the Santa Fé railway system, or southward to the Southern Pacific system, and thus give a widely extended market."

The production of the Big Bug quarry in 1892 was 2550 cubic ft. (averaging 180 lbs. per cubic ft.), which sold for from $13 to $15 per cubic ft. The value of the stone at the quarries was $3.50 per cubic ft. less. About two car-loads of stone were shipped from the Cave Creek quarries.

PETROLEUM.

The petroleum industry in 1892 will be remembered only for the low prices and for the development of the Sistersville field in Ohio and West Virginia. The famous McDonald field in Pennsylvania, which made an immense output in 1891, is still producing, but its yield has fallen far below that of its palmy days, in the latter part of 1891, when its daily production exceeded 84,000 barrels; at the end of 1892 it was but 18,000. The territory around the boroughs of McDonald and Oakdale, and the village of Noblestown, embracing a region six miles long and from one to two miles wide, which comprises the area of the McDonald field, has now been thoroughly drilled. During the autumn of 1891 only the main body of the field was opened, but in 1892 its various spurs and extensions were traced, and the production during the past year was for the most part from these. Now that all the limits of the field have been defined, it seems beyond question that the McDonald was one of the most spotted pools ever opened. For this reason the results of drilling were so very uncertain that it has been estimated that a third more money was lost in the field than was taken out of it. A number of firms and individuals "struck it rich," but the great majority of people who invested in its wells never got back the money they put in.

The greatest activity in 1892 and the most important developments were in what is now known as the Sistersville field, 40 miles below Wheeling, West Va., on both sides of the Ohio River. The first discoveries in this field were made a little more than a year ago, but it was not until late in the spring that its importance was demonstrated. Nearly 200 wells have been drilled up to the present time, and it is generally believed that the producing sand has been well defined, with the exception of a narrow streak toward the southwest, on the West Virginia side of the river. The Sistersville oil is found in the Big Injun sand at a depth of from 1400 to 1600 ft. Most of the wells produce from five to twenty times more salt water than petroleum, and frequently a well will give brine for weeks before oil shows in any considerable quantity. The field as now outlined is about four miles wide from east to west, and five miles from northeast to southwest. Within the defined limits there is still much ground which has not yet been drilled, but

it is scarcely expected that Sistersville will ever attain such prominence as McDonald had.

No new pools of importance have been developed in the Ohio fields, although spurs and extensions of the old ones have been followed up, and occasionally a good well has been found. In Indiana most of the work has been done in the vicinity of Portland, Jay County, in the northeastern part of the State, but the results have not been wholly encouraging. The sand, it is said, is extremely spotted and treacherous, and the yield of the wells developed is too small to pay in the long run. Outside of Jay County very little has been done in this State.

A number of wells have been drilled in Kentucky, but as yet nothing has been developed which indicates that the State will become an important producing region. Its oil is found in the Trenton limestone, and is of about the same quality as the Ohio oil; but the districts in which it occurs are remote from the railroads or rivers, and, as there are no pipe-lines through the country, there is no market for the product. Kentucky may sometime attain prominence in the petroleum industry, but its fields will be neglected so long as there are better ones nearer the markets.

In Colorado, in the Florence district, which remains the only producing field, the past year was a fairly prosperous one. Many new wells were sunk, and a number of them became producers, several giving greater yields than any heretofore opened in the region. Operations in this field are carried on by four large companies—the Florence, United, Triumph, and Rocky Mountain—from the wells of which a daily production approximating 2000 barrels was made in 1892. This is a considerable increase over 1891. The most important feature of recent development at Florence has been the extension of the producing area, and an effort is now being made by the producers to extend the market for the Colorado product, which has hitherto been somewhat limited. Early in the year the Rocky Mountain Oil Company completed a new refinery at Overton, near Pueblo, which has been running continuously since that time.

In California the production of petroleum in 1892 shows a large increase. The output in 1891 amounted to only 350,000 barrels, while the yield in 1892 is estimated at 485,000, of which Santa Barbara County produced 250,000; the Pacific Oil Company, Los Angeles County, 150,000; the Puente district, Los Angeles County, 35,000; while 50,000 barrels came from other localities. The petroleum industry in California is of great importance to that State, owing to the high cost of coal, and there is an active demand for crude petroleum for fuel purposes. During the current year it is expected that a still larger output of oil than in 1892 will be made, as various companies with good financial backing are sinking new wells in Ventura and Los Angeles counties, and in some new fields which furnish good prospects, but which have not yet commenced to produce.

Several new and independent pipe-lines were completed and put in operation during 1892. First, the W. L. Mellon line was laid from the McDonald field in Pennsylvania to Coraopolis, from which point the oil was shipped in tank cars to the independent refiners. Subsequently, the Producers' Oil Company laid a line to Coraopolis, and also commenced shipments by tank cars. Later in the year W. L. Mellon organized the Crescent Pipe Line Company, and constructed

a pipe-line from the McDonald field to Marcus Hook, a point on the Delaware River below Philadelphia; this line was completed in October. Then the Producers and Refiners' Pipe Line Company was organized, and a line was laid from the McDonald field north through the Butler County region to Oil City and Titusville, where most of the independent refiners are situated. This line also was completed and put into operation before the end of the year. A line is now being laid by the United States Pipe Line Company through the northern counties of Pennsylvania, to connect the northern end of the Producers and Refiners' line with the seaboard. Construction work is now in progress, and the projectors of the line expect to be able to pump oil before April 1. What effect this new line will have upon the petroleum market remains to be seen, but great things are expected of it. At present the Standard Oil Company practically controls prices, being the only buyer and at the same time itself a large producer.

UNITED STATES: PETROLEUM PRODUCTION AND EXPORTS, QUANTITIES AND VALUES, 1864–92.

(1 = 1000 in quantities and values.)

Calendar Years.	Production, Crude. Gallons.	Exports.											
		Crude Petroleum.		Naphtha.		Illuminating.		Lubricating.		Residuum and all Others.		Paraffin.	
		Gallons	Value	Gallons	Value.	Gallons	Value.	Gallons	Value.	Gallons	Value	Pounds	Value.
			$		$		$		$		$		$
1864	88,877	9,981	3,864	438	154	12,792	6,764	*a*	*a*	*a*	*a*	68	25
1865	104,903	12,294	6,869	481	174	12,722	9,521	*a*	*a*	*a*	*a*	111	38
1866	151,103	16,058	6,016	673	189	34,256	18,626	*a*	*a*	*a*	*a*	188	65
1867	140,587	7,344	1,864	225	34	62,687	22,509	*a*	*a*	*a*	*a*	352	35
1868	153,137	10,030	1,565	1,517	268	67,910	19.978	*a*	*a*	*a*	*a*	271	47
1869	177,030	13,426	2,999	2,673	446	84,403	27,631	135	51	*a*	461	....	....
1870	220,951	10,403	2,237	5,423	565	97,903	29,864	7	3	*a*	*a*	2	0.4
1871	218,620	11,279	2,171	8,397	896	132,179	33,493	240	92	101	10	37	5
1872	264,314	16,364	2,761	8,688	1,307	118,260	29,456	438	180	568	57	*a*	14
1873	415,539	19,644	2,665	10,250	1,267	207,596	41,358	1,503	517	1,377	118	*a*	42
1874	458,932	14,431	1,428	10,617	997	206,563	30,169	993	270	2,505	118	*a*	65
1875	510,826	16,537	1,739	14,049	1,392	203,679	28,169	938	266	2,324	170	*a*	110
1876	383,572	25,343	3,344	13,253	1,502	220,832	44,089	1,158	370	2,864	239	*a*	222
1877	560,715	28,773	3,267	19,566	1,939	307,374	51,366	1,914	578	4,256	391	*a*	163
1878	646,668	24,050	2,170	13,432	1,077	306,213	36,856	2,526	699	3,127	221	1,735	156
1879	836,394	28,602	2,069	19,525	1,368	365,597	32,812	3,169	713	4,828	273	3,634	302
1880	1,104,017	36,748	2,772	15,115	1,345	286,132	29,048	5,607	1,142	3,178	199	4,234	392
1881	1,161,772	40,430	3,089	20,655	1,981	444,667	42,123	5,054	1,166	3,756	197	5,370	437
1882	1,231,455	45,011	3,373	16,970	1,304	428,425	37,636	8,822	2,034	4,265	275	9,121	579
1883	984,885	59,019	4,439	17,365	1,195	440,151	39,470	10,108	2,193	6.503	465	16,562	1,124
1884	1,017,174	79,679	6,103	13,676	1,133	433,851	39,451	11,985	2,443	5,303	328	19,757	1,412
1885	917,583	81,436	6,041	14,739	1,161	445,881	39.476	12,979	2,659	5,714	335	25,349	1,868
1886	1,178,723	76,346	5,068	14,475	1,265	485,121	39,013	13,948	2,689	1,994	110	27,432	1,844
1887	1,187.712	80,650	5,142	12,382	1,049	485,242	37,007	20,583	3,559	2,989	141	33,135	2,049
1888	1,159,705	77,549	5,455	13,481	1,083	455,045	37,236	24,510	4,215	1,871	116	34,751	2,104
1889	1,476,867	85,190	6,134	13,984	1,208	551,769	41,215	27,903	4,639	1,858	97	40,965	2,288
1890	1,924,552	96,573	6,535	12,462	1,051	550,873	39,826	32,091	4,767	1,831	92	59,693	2,920
1891	2,267,425	96,723	5,366	11,424	868	531,445	34,880	33,210	5,000	1,003	61	65,076	3,979
1892	2,282,469	104.397	4,696	16,393	1.038	589,418	31,826	34,027	5,130	403	38	69.876	4.160

(*a*) Not stated. **Exports from 1864 to 1871 in fiscal years; all other dates in calendar years.**

Operations on the petroleum exchanges have been small, and the market has been stagnant, with small fluctuations in prices throughout the year. The volume of transactions on the New York Exchange has been unusually small, and the Bradford Exchange has abolished its clearing-house for lack of business. The average market price of crude oil during 1892 was lower than in any previous year. The monthly and yearly average price of pipe-line certificates, or crude petroleum at the wells, since 1882 is given in the following table:

AVERAGE PRICE OF PIPE-LINE CERTIFICATES, OR CRUDE PETROLEUM, AT THE WELLS.

Months.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
January	$0.83⅛	$0.93¾	$1.11	$0.70⅞	$0.88⅜	$0.70	$0.91¼	$0.86⅝	$1.05¾	$0.74¼	$0.62⅜
February	.84½	1.01	1.04⅜	.72⅜	.79⅞	.64⅝	.91⅝	.89¼	1.05⅛	.78⅜	.60¼
March	.81⅝	.97⅝	.98⅛	.80⅛	.77¼	.63⅜	.93⅝	.90⅞	.90	.74¼	.57⅛
April	.78⅝	.92⅜	.94	.78½	.74⅛	.64⅞	.82⅝	.88	.82⅝	.71½	.57⅞
May	.71½	1.00⅛	.85⅝	.79	.70	.64⅛	.86¾	.83⅛	.88⅞	.69¾	.57⅜
June	.54⅜	1.16⅜	.68⅝	.82	.66½	.62⅝	.75⅞	.83⅞	.89¼	.68⅛	.54⅛
July	.57 4/10	1.05⅞	.63½	.92½	.66	.59¼	.80⅝	.95⅛	.89⅛	.66½	.52½
August	.58⅝	1.08½	.81⅛	1.00¼	.62⅛	.60⅛	.90⅛	.99½	.89¼	.64	.55
September	.72⅛	1.12½	.78	1.00¾	.63⅜	.67	.93⅝	.99⅛	.81⅞	.58½	.54⅜
October	.93¾	1.11⅛	.71⅛	1.05½	.65⅛	.70⅞	.90⅝	1.01⅜	.80⅛	.60¼	.51⅜
November	1.14	1.14½	.72½	1.04⅜	.71⅝	.73⅞	.85⅜	1.08½	.72⅜	.58¾	.52
December	.96	1.14⅛	.74⅛	.89⅞	.70¼	.80¾	.89¼	1.04⅛	.67¼	.59⅛	.53¼
Average	.78⅞	1.05¾	.83½	.88	.71½	.66¾	.87⅝	.94⅛	.86⅘	.67	.55⅝

The following table, compiled by Mr. Joseph D. Weeks for the years 1859 to 1890, both inclusive, is taken from the *Mineral Resources of the United States*, 1889 and 1890. The total for 1891 is official, but that for 1892 and the distribution by States for both years are partly estimated.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES SINCE 1859. (*a*)

(Barrels of 42 gallons.)

Years.	Pa., N. Y.	Ohio.	W. Va.	Colo.	Cal.	Ind.	Ky. and Tenn.	Other. (*f*)	Total.
1859	2,000	....	....	....	....	....	....	....	2,000
1860	500,000	....	....	....	....	....	....	....	500,000
1861	2,113,609	....	....	....	....	....	....	....	2,113,609
1862	3,056,690	....	....	....	....	....	....	....	*b*3,056,690
1863	2,611,309	....	....	....	....	....	....	....	2,611,309
1864	2,116,109	....	....	....	....	....	....	....	2,116,109
1865	2,497,700	....	....	....	....	....	....	....	2,497,700
1866	3,597,700	....	....	....	....	....	....	....	3,597,700
1867	3,347,300	....	....	....	....	....	....	....	3,347,300
1868	3,646,117	....	....	....	....	....	....	....	3,646,117
1869	4,215,000	....	....	....	....	....	....	....	4,215,000
1870	5,260,745	....	....	....	....	....	....	....	5,260 745
1871	5,205,234	....	....	....	....	....	....	....	5,205,234
1872	6,293,194	....	....	....	....	....	....	....	6,293,194
1873	9,893,786	....	....	....	....	....	....	....	9,893,786
1874	10,926,945	....	....	....	....	....	....	....	10,926,945
1875	8,787,514	*d*200,000	*d*3,000,000	....	*d*175,000	....	....	....	*c*12,162,514
1876	8,968,906	31,763	120,000	....	12,000	....	....	....	9,132,669
1877	13,135,475	29,888	172,000	....	13,000	....	....	....	13,350.363
1878	15,163,462	38,179	180,000	....	15,227	....	....	....	15,396,868
1879	19,685,176	29,112	180,000	....	19,858	....	....	....	19,914,146
1880	26,027,631	38,940	179,000	....	40,552	....	....	....	26,286,123
1881	27,376,509	33,867	151,000	....	99,862	....	....	....	27,661,238
1882	30,053,500	39,761	128,000	....	128,636	....	*e*160,933	....	*e*30,510,830
1883	23,128,389	47,632	126,000	....	142.857	....	4,755	....	23,449.633
1884	23,772,209	90,081	90,000	....	262,000	....	4,148	....	24,218,438
1885	20,776,041	650.000	91,000	....	325,000	....	5,164	....	21,847,205
1886	25,798,000	1,782,970	102,000	....	377.145	....	4,726	....	28,064,841
1887	22,356,193	5,018,015	145,000	76,295	678,572	....	4,791	....	28.278,866
1888	16,488,668	10,010,868	119,448	297,612	690.333	....	5,096	....	27,612,025
1889	21,487,435	12,471,466	544.113	316,476	303,220	33,375	5,400	2,028	35,163,513
1890	28,458,208	16.124.656	492,578	368,842	307,360	63,496	6,000	1,532	45,822,672
1891 (*g*)	35,742,152	17.740,301	2,406,218	665,482	323,600	136,634	9,000	1,504	57,024,891
1892 (*g*)	33,332,306	19.500,000	3,000.000	700,000	485,000	140,000	9,000	1,600	57.167.906

(*a*) Some oil was produced in other States, but no record has been secured other than that contained in Note *b*.

(*b*) In addition to this amount, it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee.

(*c*) Including all production prior to 1876 in Ohio, West Virginia, and California.

(*d*) Includes all production prior to 1876.

(*e*) This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

(*f*) Illinois, Kansas, Texas, and Missouri.

(*g*) The production for 1892 and the distribution for 1891 are partly estimated.

The condition of the wells in the different districts is shown in the following table, which presents the industry as it was on the 31st of December, 1892, the production being given in barrels.

CONDITION OF THE PETROLEUM INDUSTRY, DECEMBER 31, 1892.

(Production in barrels.)

Locality.	Wells Completed.	Production.	Wells Dry.	New Wells. Drilling.	New Wells. Rigs.	Total.
New York, Pennsylvania, and West Virginia:						
Alleghany	4	10	3	1	0	1
Bradford	1	10	5	0	2	2
Butler and Armstrong	18	277	6	41	12	53
Middle Field	10	25	1	7	3	10
Southwest District	102	7,225	20	166	83	249
Venango and Clarion	8	37	6	9	9	18
Total	143	7,580	35	229	109	338
Buckeye, Ohio:						
Allen	1	20	0	2	1	3
Auglaize	12	177	2	5	8	13
Hancock	3	65	0	2	2	4
Sandusky	6	505	0	7	4	11
Wood	74	4,025	8	62	33	95
Miscellaneous	9	115	5	3	1	4
Total	105	4,907	15	81	49	130
Southeastern Ohio:						
Macksburg and Perry, etc.	2	0	2	9	13	22
Indiana:						
Adams	13	460	4	0	0	0
Blackford	2	60	0	5	5	10
Jay	23	2,290	15	14	12	26
Wells	9	350	2	5	2	7
Total	47	3,160	21	24	19	43
Grand total	297	15,647	73	343	190	533

PHOSPHATE ROCK.

By Francis Wyatt, Ph.D.

The phosphate industry of America has now grown to such enormous proportions that, since the discovery of the vast deposits of Florida, our mines now fairly dominate the markets of the world. The eyes of all who are interested in future developments are therefore anxiously turned toward Florida and South Carolina, and it is difficult to foretell what may be the final outcome of the embarrassing position so faithfully outlined in the following pages. Aside from the desirability of forming some kind of rational combination, what shall eventually regulate the output and restore prices to a more satisfactory level ? So far as our exports are concerned it is probable that the attention of capital will soon be turned to the manufacture of concentrated superphosphate at or near the mines. A great deal has already been written in the pages of the *Engineering and Mining Journal* upon the prevailing custom of throwing the entire cost of mining—especially in Florida—upon the higher grade material, leaving all second grades upon the mines as practically worthless material. The time now seems ripe for a radical change in this extravagant system, and for the adoption of a rational plan of work whereby these second and lower grades may all be utilized for the extraction of their phosphoric acid, which, in its turn, would take the place of oil of vitriol as a solvent or acidulator of the higher grades. There is no lack of available localities, either upon the Gulf or on the Atlantic coast, where chemical fertilizer factories could be advantageously established, and we have an abundance of the necessary sulphur, both in the form of iron pyrites and of native brimstone. The important economy in the matter of transportation alone that would be at once effected by this plan is sufficient to commend it to thoughtful operators, and there can be no doubt that it would further facilitate our ultimate complete control of the world's markets. The direct manufacture of phosphorus from these phosphates at the mines is also worthy of study and experiment, and will no doubt receive attention in the near future.

Phosphates: Their Production and Consumption.

In the statistical number of the *Engineering and Mining Journal* for 1891 I entered fully into the various phases of the phosphate industry, and endeavored to give some rational explanation of its abnormal, not to say disastrous, condition. The year which has just closed has not failed to realize the pessimistic views then expressed. The markets of the world have continually gone from bad to worse; most of our producers have been selling their products at mere cost, and are at the present time actually confronted by the alternative of shipping them at a loss or closing down their works. Such is the irony of fate! Four or five years ago we were asking ourselves whence the world was to get its future supplies, and were disposed to hail with more than satisfaction the advent of the basic slags. To-day, by the axiomatic "development of the unforeseen," the question has been turned upside down, and now is, What can be done with the surplus natural phosphates, and how can they be sold at a price low enough to prevent competition from basic slags or any other by-product of manufacture?

The figures given last year as to the possible consumption of phosphates do not appear to have carried conviction, but a further inquiry has enabled me to estimate the amount of phosphoric acid yearly taken from the cultivated soils of both Europe and America as some 6,000,000 tons. Of this total, however, the actual quantity given back to the soils each year in the form of phosphatic fertilizer does not exceed 25%, half of which only is derived from a mineral source. Proceeding upon this basis, confirmed by diligent and impartial inquiry, if an average of 30% be adopted as representing the grade of the world's most productive deposits, about 750,000 tons of phosphoric acid, or 2,500,000 tons of mineral phosphate, is the utmost quantity at present required for the world's agricultural consumption. This is a vast amount of material, but it does not reach the agriculturist in its raw form. It is mostly ground up, mixed with sulphuric acid, and transformed into what is popularly known as soluble phosphate or superphosphate. The staple commercial grade or quality of this familiar fertilizer, as well in this country as in England, France, Germany, and Belgium, is made to contain from 10% to 13% of soluble phosphoric acid. In Germany, however, and to a small extent in England also, there is a limited demand for "supers" of a higher grade; and, so far as I can ascertain, the two countries together manufacture some 150,000 tons of a quality averaging from 17% to 18%. Special stress is laid upon these facts, because it follows from them that outside of the 80,000 tons required for this manufacture of exceptionally high grade, the only use for the richer kinds of phosphate rock is to mix them with such lower grades as do not attain the maximum limit required to produce a 13% superphosphate! To give an example: There are vast, not to say inexhaustible, deposits in Belgium and France, which do not average more than 40% of bone phosphate. While these are extremely cheap to mine, and are readily accessible by rail and water to the chief centers of European manufacture, it is necessary to mix them with proper proportions of higher grade material in order to produce a fertilizer of sufficient strength. The actual consumptive demand for high-grade phosphate rock is

therefore very limited: 100,000 to 125,000 tons, either for direct use or for mixing purposes, is as much as the markets can at present absorb without being overcrowded.

Until a very recent period there has been no plethora of this rock of high grade: its price has consequently ruled very high, and its exploitation has generally been a remunerative operation for capital. To-day the equilibrium between supply and demand has been destroyed; the old-established conditions are threatened with revolution, and what was once at a premium is a drug in the market. The Florida developments have not only caused the amount of high-grade rock required to be exceeded, but they have produced and forced upon the markets immense quantities of lower grades, which can be used without the necessity for any enriching material. The reason why 75% to 80% rock should retain an exceptional value consequently no longer exists, and so it has sunk to a common level with the poorer products.

Before the discovery of Florida phosphates the South Carolina mines furnished about one fifth of the world's demands. Their product was entirely suitable for the direct manufacture of a 13% soluble "super," and some 150,000 tons were annually exported. The very high grade products of Canada and Norway, as well as those of Aruba, Sombrero, and the Somme, were about sufficient in quantity to enrich the poorer grades of Belgium, France, and England; but when Florida came into the field there was an inevitable collapse. Two years ago the price of 75% to 80% phosphate of lime was 1s. 3d. per unit, with a rise of one fifth of a penny per unit for all deliveries containing more than the minimum.

The Aruba Phosphate Company, in its financial statement and report for the year ending Sept. 30, 1891, was thus able to show a dividend of 72% per annum—a fair example of the phosphate business at that time. To-day the market price of the same material is 8d. per unit, there is no more consumptive demand for it now than there was then, and all the mines producing it, with the exception of those of Florida, have practically shut down.

Florida has succeeded in tripling its exports of phosphate rock; has compelled consumers to acknowledge its industrial value, and has forced the majority of foreign producers to retire from the field. This is certainly no mean achievement; but what profit has been made by it, or what sacrifice has it entailed? To answer this, I present a series of accurate tables of production, consumption, and exportation:

SHIPMENTS OF PHOSPHATE ROCK, IN TONS OF 2,240 LBS., FROM SOUTH CAROLINA IN 1892.

1892.	From Beaufort, S. C.			From Charleston, S. C.				
				Coastwise.				
	Crude, Foreign.	Crude, Coastwise	Total.	Crude.	Ground.	Railroads Crude.	Foreign, Crude.	Total.
January	4,101	4,204	8,305	12,040	......	7,271	......	19.311
February	5,438	1,686	7,124	9,909	......	4,002	50	13.961
March	11,207	1,133	2,340	10,106	56	5,272	.....	15,434
April	3,081	892	3.973	8.707	....	3,157	......	11,864
May	16.374	......	16,374	12,843	621	1.339	......	14.803
June	13.285	4,425	17,710	10,956	......	5,168	.....	16,124
July	29,347	1,259	30,606	12.292	1.500	1,743	2,250	17,785
August	18,688	4.229	22,917	17,275	215	7.195	.....	24,685
September	8,670	2,961	11,631	9,743	200	3,425	175	13,543
October	5,152	6,481	11,633	15,603	876	3,984	.....	20,463
November	5,000	......	5,000	8,788	529½	3,385	......	12,702½
December	......	......	......	6,000	100	2,500	.....	9,500
Total	120.343	27,270	147.613	134.862	4,097½	48,441	2,475	189,875½

PHOSPHATE ROCK (WASHED PRODUCT) MINED BY THE LAND AND RIVER MINING COMPANIES OF SOUTH CAROLINA.

	Long Tons.
1867, year ending May 31	6
1868 " " "	12,262
1869 " " "	31,958
1870 " " "	65,241
1871 " " "	74,188
1872 " " "	58,760
1873 " " "	79,203
1874 " " "	109,340
1875 " " "	122,790
1876 " " "	132,478
1877 " " "	163,000
1878 " " "	210,322
1879 " " "	199,365
1880 " " "	190,763
1881, year ending May 31	266,734
1882 " " "	332,077
1883 " " "	378,380
1884 " " "	431,779
1885 " " "	395,403
1885 (June 1 to Dec. 31)	277,789
1886 (calendar year)	430,549
1887	480,558
1888	448,567
1889	548,585
1890	537,149
1891	400,000
1892	350,000

Remarking on the decreased prosperity of the phosphate industry in South Carolina, as brought to light by these figures, Governor Tillman, in his annual report to the Phosphate Commission of that State, says that "there is a large amount of rock on hand at all the works, estimated at from 80,000 to 100,000 tons.

"Notwithstanding the fact that the mining operations were conducted outside of the Coosaw River during more than half the fiscal year, the opening of that river to all companies has resulted in an increase of the total production to figures larger than ever before known. But as the law does not require the royalty to be paid until the rock is shipped and sent to market, the State's income is less than last year. The rock is on hand, but it has not been sold, by reason of the low prices now prevailing. Eighteen months ago, or when the Coosaw litigation began, the price of rock was over $7 per ton. It is now bringing about $3.50, and the miners, unwilling to sell at these low figures, are piling it up in the expectation or hope of better prices.

"We are not at present prepared to recommend any reduction in the royalty, but it may soon become absolutely necessary."

The average cost of production per ton of South Carolina phosphate, loaded free on board outgoing vessels, is $3.50 per ton. Its actual selling price in foreign markets is 12c. per unit of phosphate delivered, and this price has been fixed by the South Carolina miners themselves, under the misguided notion that it would be the means of ending the ruinous competition by shutting down the Florida mines. The absurdity of their action and the falseness of their conclusions will be made clear by the following:

SOUTH CAROLINA PHOSPHATES.

Cost of 123,000 long tons, 57% at $3.50 per ton	$430,500
Ocean freights at $3.25 per ton	399,750
Discount, shrinkage, moisture, insurance, port dues, landing charges, sampling, etc. = 7% on $841,320.	58,892
Total cost	$889,142
Selling price @ 12c. per unit	841,320
Net loss (say 39c. per ton)	$47,822

From this disastrous condition of what was lately the most prosperous phosphate industry in the world, we turn to consider the situation in Florida.

SHIPMENTS OF FLORIDA PHOSPHATES, ROCK AND PEBBLE, OF ALL GRADES, FROM VARIOUS PORTS, FROM JAN. 1 TO DEC. 30, 1892. COMPILED FROM THE SEVERAL SHIPMENTS.

Shipments from Fernandina (all hard rock)	125,000 tons.
" from Tampa (rock and pebble)	60,000 "
" from Brunswick (all hard rock)	20,000 "
" from Punta Gorda (all pebble)	64,500 "
Sundry railroads for domestic consumption	31,000 "
Total shipments from Florida	300,000 "
South Carolina, 1892, mined and sold	350,000 "
Grand total	650,500 "

—as 1 to 0.86.

The following companies are producers: Anglo-American; Archer; Alafia River; Anglo-Florida; Black River; Belleview; Bowling Green; Charlotte Harbor; Deacon Phosphate; Excelsior Phosphate; Fort Meade Fertilizer; Florida Phosphate and Fertilizer; Fort Meade Phosphate, Fertilizing, Land, and Investment; Homeland Pebble; High Springs; Ichetuchuee; Little Brothers Fertilizing; Lake Hancock Pebble; Moore & Latum; Mastodon Pebble; North and South Alafia River; Orange County; Perrill Phosphate; Pitts Phosphate; Plate Rock; Thann Phosphate; Pebble Phosphate, of Jacksonville; Stonewall; Standard Pebble; Stranathann; Tampa; Trenton; Chicago; Hartshorn; Bradley's Phosphate Mines; Hamburg.

FLORIDA PHOSPHATES.

	Tons.		Tons.
Ocala Blue River Company............H. R.	2,100	Bartow Phosphate Company.........Pebble	3,428
Osceola Company. .... "	1,987	Brooks & Baker Mine ....H. R.	1,700
Clark, Ladmann & Co.................. "	8,782	P. R. & Royal Phosphate Co.(Pebble 1143) "	2,125
Dunnellen Phosphate Company... ... "	27,723	Peace River Phosphate Company Pebble	25,821
Florida Phosphate Co ...(Pebble 2053) "	12,291	Jacksonville & P. R. Co...(Pebble 888) H. R	1,868
Illinois Phosphate Company....... ... "	10,038	Virginia and Florida Company.......Pebble	980
Marion Phosphate Company........... "	5,850	United States Phosphate Company.. "	978
B. Arentz & Co .... "	14,926	Peru Phosphate Company.......:... "	653
Empire State Phosphate Company.... "	7,388	Bone Valley Company..... .... "	3,990
Carney Phosphate Company . ... "	510	South Chemical Company............ "	587
Early Bird Phosphate Company....... "	5.950	Peruvian Phosphate Company..... .. H. R.	306
Eagle Phosphate Company... .. .. "	1.034	Land & Pebble Company............Pebble	1,408
Eagle & Eureka Company........ .... "	2,007	National P. R. Company.............. "	2,408
Pebble Phosphate Company........... "	4,731	Sundries estimated for December.....H. R.	6,660
Cie des Phosphate de France.......... "	14,332	High Spring Phosphate Company..... "	1,932
Thos. D. & F. Co....................... "	590	Dutton & Co........ .... "	9,275
Aibion Phosphate Company........... "	4,202	Sundries estimated for December..... "	2,600
Standard Phosphate Company. .... "	3,604	Charlotte Harbor Phosphate Co......Pebble	36,167
Sundries estimated for December..... "	7,902	Gulf Phosphate Company............ "	2,450
Netherlands Company................ "	10,578	Sundries estimated for December.... "	5,000
S. D. Wright & Co..................... "	1,621		
A. D. Wright........ .... "	1,900	Total..........	260.382

From Fernandina, 124,900 tons; Tampa, 50,980 tons; Brunswick, 20,000 tons; Punta Gorda, 64,502 tons—total, 260,382 tons; home consumption, 31,000 tons—grand total, 291,382 tons, of which the United States used 66,292 tons and exported 225,090 tons.

While South Carolina, however, enjoys the advantage of a very large local domestic demand from her well-established fertilizer factories, Florida, as a new and comparatively unknown source of supply, is not favorably known in domestic markets. She has therefore sent the great bulk of her products abroad. It will not be forgotten by readers of *The Engineering and Mining Journal,* and by others well posted in the phosphate trade, that at the close of the year 1891 the selling prices for Florida phosphates, delivered free on board vessels, were, respectively, $6 per ton for the pebble phosphate of from 60% to 65% grade, and $9 per ton for the hard rock of from 75% to 80%.

At the same period the average cost of winning both these grades and putting them free on board cars at the mines was:

For the pebble phosphate	$2.75 per long ton.
For the hard rock "	5.00 " " "

As this estimate has been the subject of some adverse criticism, I have obtained exact figures this year from the books of three of the largest producers of "hard rock," and have also been favored with a reliable and detailed statement of actual cost from two large pebble-miners. The names of the companies are suppressed.

Hard Rock Phosphates.—Twenty-three thousand long tons, 77% mined, partially washed, dried, and loaded on cars at the mines, including superintendent's and chemist's salary, but without counting interest on capital or allowing for expenses of management, $4.23.

Pebble Phosphate.—Seven thousand long tons, average 65% mined, washed, dried, sifted, and loaded on cars or scows at the mines, including management, but without counting interest on capital invested in lands and in plant, $2.80.

The railway freight and shipping charges on the hard rock from the mines to Fernandina, from which the bulk of the rock was exported, is $2.50 per long ton; while that on the pebble phosphate to Charlotte Harbor is only about 70c. These working results confirm my first estimate, though in some very exceptional cases the respective costs may have been a little less than those quoted.

Cost of hard rock phosphate, 175,000 tons, 75% at $6.75 per ton, free on board at shipping port	$1,177,750
Ocean freight at $4 per ton	700,000
Discount, shrinkage, moisture, insurance, port dues, landing charges, sampling, at 7% on $2,100,000	147,000
Total cost	$2,024,750
Value in foreign market 175,000 tons, 75%, at 16c. per unit	2,100,000
Net profit (say 43 cents per ton)	75,250
Cost of pebble phosphate, 80,000 tons, 65%, at $3.50, free on board at shipping port	280,000
Ocean freight at $3.50 per ton	280,000
Discount, etc. at 7% on $624,000	43,680
Total cost	$603,680
Value in foreign market at 12c. per unit	624,000
Net profit (say 25½c. per ton)	$20,320

This, then, seems to be the answer to the question ; What profits have we derived or may we expect to derive from the exploitation of our valuable reserves of phosphate? South Carolina, so recently doing a prosperous business, can now only hope to keep a place in the markets by selling at a very tangible loss; and Florida, on the basis of her present output, with an expenditure of over $2,000,000 for labor and freights, cannot hope to realize a gross profit on her total export business of more than $125,000. The situation is practically the same to-day as it was last year. The demand for phosphate has not increased, and we have only succeeded in securing customers for our abnormally large output by "cutting rates" so low as to push out all our neighbors and leave ourselves without the necessary margin for interest on our capital or profits for our labor. Buyers have lost all confidence in the article, and have concluded that since we can produce it for nothing, we should sell it for a song. They are continually looking for a "lower man," and hold themselves tranquilly aloof, while the brokers pelt them with offers.

Phosphate-Mining in Canada.

A correspondent in Montreal contributes the following:

"During the past twelve months Canada has experienced great depression in the phosphate-mining industry, owing to heavy stocks of fertilizers being held over in England and on the Continent, and to the falling off in the sale of fertilizers during the past two years. The exports of Canadian high-grade phosphates in 1891 were in the vicinity of 25,000 tons, but this year only 8000 tons have been shipped, and about 8000 tons are being carried over. The prices in the United Kingdom in 1891 were from 13d. to 16d. per unit, while in 1892 they fell to 10d. per unit for 80% or better. In the Buckingham district but three companies out of fifteen are working—namely, the High Rock Phosphate Company, of London, England, the Anglo-Continental Guano Company, and the General Phosphate Corporation. The first-named company has for the past fifteen years worked its property with from 150 to 200 hands, and the last named in 1891 worked about 175 hands. Last year the three companies did not work more than 100 or 125 hands. In the Templeton district for the past fifteen years about 600 men have been employed, while in 1892 not more than 100 men were working. The monthly output of phosphate in these two districts did not exceed 5000 tons, which, with the 8000 tons carried over, will most likely be shipped to England and the Continent next season at the prevailing prices. English and German contracts for fertilizers are usually made in February and March, and better prices are anticipated for 1893. Competition between South Carolina and Florida low-grade phosphate has practically killed Canadian seconds, and the only market now left open for the 70% grade is in Chicago and the Western States. A sale of 1000 tons for Chicago was recently made by a Templeton company at $6.50 per ton for ground 65% in bags, free on board at Buckingham, P. Q. On several other phosphate properties in the Buckingham and Templeton districts mica discoveries have been made, which have given new values to what were considered a short time ago almost worthless properties; and one great advantage in this is that it reduces the cost of mining phosphate considerably, as these minerals are often found in conjunction with each other. In the Kingston and Perth districts not more than 2000 tons of 80% were mined in 1892, and this season the production will not exceed 500 tons. The cost of production of Canadian phosphate is estimated at about $12 per ton of 2240 pounds, free on board ship at Montreal. The ruling prices in 1892 ranged from $13 to $14.50 per ton."

THE PLATINUM GROUP OF METALS.

By Charles Bullman, M.E.

History.—Don Antonio de Ulloa, who accompanied the party sent by France to South America in 1735 to measure an arc of the meridian on the equator, is generally credited with first introducing platinum into Europe, having obtained it from the mines of El Choco, on the west coast of Colombia. Roscoe and Schorlemmer in their *Treatise on Chemistry* intimate that platinum was known in Europe at a much earlier date, and it would be strange if it were not so, as the mines at Noonamâ, Tamaná, and Sipi, which contain gold and platinum in nearly equal quantities, were opened in the early part of the seventeenth century, if not before.

Native platinum was first described as a metal by William Watson in 1741, it having been obtained from Charles Wood, who brought it from Cartagena, Colombia. In 1752 Scheffer of Stockholm, who called it "white gold," described its insolubility in nitric acid, its infusibility alone, and its fusibility with arsenic. Marggraf was probably the first experimenter to isolate the pure metal, for in 1757 he discovered that platinum chloride produces with potassium and ammonium chlorides an orange-yellow precipitate, which if ignited is decomposed, with the formation of spongy platinum.

For some time but little was done with the metal in Colombia, although small quantities found their way to Europe, but the greater part was thrown away because there was no market for it. In 1778 the King of Spain issued an order commanding all miners to send the platinum found to the Royal Treasury; but as no recompense was offered, little attention was paid to this mandate. In 1788 the king offered $2 per pound for the metal, and, according to Don Vincente Restrepo of Bogota, there was obtained in that year 3820 lbs.

Platinum occurs in nature alloyed with iron, iridium, rhodium, ruthenium, palladium, and osmium, which metals, with the exception of iron, are closely related through chemical and physical affinities, and form what is known as the platinum group: it will be easier, therefore, to speak of their occurrence and mining as a group—and, subsequently, to treat their metallurgy under separate captions.

PLATINUM.

Occurrence.—Platinum and the associated metals are widely distributed, but in very few localities do they occur in quantities of economic importance. The platinum of commerce is obtained wholly from alluvial deposits, for although it has been found *in situ*, such occurrence is rare and never in sufficient quantity to be

profitably exploited. The commonly associated minerals in the alluvial deposits are magnetic iron-sand, iridosmine, topaz, epidote, chromite, garnet, and occasionally zircon, ilmenite, serpentine, chrysolite, peridote, diamond, and quartz. It is commonly, though probably erroneously, asserted that iridosmine is an invariable accompaniment of platinum.

In Russia platinum was found in the Siberian Ural Mountains in 1819, but was not identified until 1823. To Humboldt, who with Rose and Ehrenberg visited the Russian deposits in 1829, we owe much of the early history of these fields. The present diggings in Russia are at Goro-Blagodat, belonging to the Government, and at Nischni Tagilsk, the property of Prince Demidoff. Neither of these properties is auriferous. Formerly there were platinum and gold washings at Bogoslowsk, Miask, and New Jansk. Iridosmine also occurs in considerable quantity in all these deposits.

In Colombia the chief and the only washings of importance are found in the Province of San Juan, Department of Cauca, forming the southern part of what is known as El Choco. The principal localities are the districts of Sipi, Tamaná, Condoto, Iro, and San Juan, in all of which the metal is found associated with gold. Platinum is also found in the Atrato and its tributaries, in Antioquia, and in the district of Barbacoas.

In Brazil native platinum occurs in the auriferous gravels of Minas Geraes, associated with iridosmine, platiniridium, and an alloy of palladium and gold, and also in grains in the auriferous veins of the Boa Esperança in the Province of Parahyba do Norte,* while the gold of the Gongo Soco *jacutinga* of Minas Geraes is frequently found alloyed with platinum, and occasionally with palladium.† The platiniferous deposits of Brazil are further distinguished by two very rare native alloys—porpezite, a palladium-gold alloy occurring at Porpez, and rhodium gold.‡

In Borneo platinum is found in certain auriferous gravels of which little is known, although some years ago it was reported that from 600 to 800 lbs. per year were being extracted from them. The rare mineral laurite, a sulphide of ruthenium, occurs there in small quantities in conjunction with the platinum.

In New South Wales platinum is found in the sand beaches of the Richmond and Tweed rivers, and *in situ* in the Broken Hill district, occurring in a ferruginous felsite and granite.§

In New Zealand it is reported by Major J. A. Pond ‖ as having been found in rounded grains and octahedral crystals in a quartz vein in the shaft of the Queen of Beauty Mining Company. ¶ It occurs in the sands of the Tayoka River.

In British Columbia important deposits of platiniferous gold gravels are found on the Similikameen River and its tributaries, especially the Tulameen. It is also found in the Frazer River district, near Lillooet.

In 1888 a mineral containing 52.57% of platinum, in combination with arsenic,

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* Hartt, *Geology and Physical Geography of Brazil.*

† Phillips, *Ore Deposits.*

‡ *Chemical News*, 46, 216, 1882, and *Ann. Chim. et Phys.*, xxix., 137, 1827.

§ Mingaye, *Annual Report of Mines of New South Wales*, 1891.

‖ *Trans. New Zealand Inst.* xviii. 401, 1885.

¶ The occurrence in rounded grains and crystals at the same time is inexplicable and throws doubt on the report.—THE AUTHOR.

was discovered at the Vermilion nickel mine at Sudbury, Ontario, but so far this mineral has proved of no economic importance.* It was first described by Prof. H. A. Wells, who named it sperrylite.†

In the United States native platinum occurs in many localities, but not in sufficient quantity, thus far, to be worked with profit. Near Plattsburg, N. Y., according to Prof. Collier, a single specimen was found which weighed 104.4 grains, 44% of which was platinum, and 56% chromite.‡ In California it frequently occurs, associated with iridosmine, in the auriferous gravels, and in Humboldt County it is found in the auriferous sands of the Gold Bluff Beach, near the mouth of the Klamath River.

Besides the above-named localities, platinum has been found at the following places: *Europe*—Lapland, Avalo River (associated with diamonds); Ireland, Wicklow County; Germany, Tilkerode; France, Aroy; Switzerland, Val du Drac; Spain, Guadalcañal (in argentiferous *fahlerz*). *India*—at Ava. *North America*—Alaska, Yukon River; Canada, St. François, Beauce County, Quebec; United States, Alabama; Arizona; California, in Siskiyou County; at Oroville and Cherokee, Butte County; in Anderson Valley and Navarro River, Mendocino County; in Nelson Creek, Badger, and at Gopher Hills, Plumas County; in Dutton's Creek and North Fork, Trinity County, and at Tuolumne River, Tuolumne County; Georgia, Lumpkin County; North Carolina, near Rutherford; Oregon, near Waldo, Josephine County; at Port Orford and Eckley, Currie County, and near Randolph in Coos County; Mexico, at the Las Yedras mine, Sinaloa; Honduras, Choloteca and Gracias; and in Santo Domingo (with gold) in the Jacki River.

The following table shows the composition of native platinum, iridosmine, platiniridium, and sperrylite, as reported by a number of investigators:

ANALYSES OF NATIVE PLATINUM.

	Pt.	Ir.	Rd.	Pd.	Ru.	Os.	Au.	Osmiridium.	Fe.	Cu.	Sand.	Pb.	Fe_2O_3	CuO.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Russia	77.50	1.45	2.80	0.85	....	2.30	....	2.35	9.60	2.15	1.00	....	....	....
"	76.40	4.30	0.30	1.40	....	....	0.40	1.40	0.50	11.75	1.40	...	....	....
"	85.97	0.54	0.96	0.75	....	0.54	....	...	6.54	0.86	2.10	....	....	....
Colombia	86.20	0.85	1.40	0.50	....	....	1.00	0.95	7.80	0.60	0.95	....	....	....
"	80.00	1.55	2.50	1.00	....	....	1.50	1.40	7.20	0.65	4.35	....	....	....
"	76.82	1.18	1.22	1.14	....	....	1.22	7.98	7.43	0.88	2.41	....	....	....
California	85 50	1.05	1.00	0.60	..	....	0.80	1.10	0.75	1.10	2.95	....	....	....
"	76.50	0 85	1.95	1.30	....	1.25	1.20	7.55	6.10	1.25	1.50	0.55	....	....
Oregon	51.45	0.40	0.65	0.15	....	...	0.85	37.80	4.30	2.15	3.00	....	....	....
New South Wales	59.80	2.20	1.50	1.50	...	....	2.40	25.00	4.30	1.10	1.20	....	....	....
Borneo	70.21	6.13	0.50	1.41	....	1.15	3.97	....	5.80	0.34	8.86	...	1.13	0.50
Spain	45.70	0.95	2.65	0.85	....	....	3.15	2.85	6.80	1.05	35.95	....	....	....
British Columbia	78.43	1.04	1.70	0.09	....	...	....	3.77	9.78	3.89	1.27	....	....	...

ANALYSES OF IRIDOSMINE.

	Pt.	Ir.	Rd.	Pd.	Ru.	Os.	Au.	Osmiridium.	Fe.	Cu.	Sand.	Pb.	Fe_2O_3	CuO.
Russia	1 10	77.20	0.50	...	0.20	21.00	....	....	....	trace	...	....	..	....
"	0.14	43.74	1.65	...	4.68	48.85	...	....	0.63	0.11	...	...	....	....
Colombia	0.10	70.40	12.30	....	...	17.20	...	....	..	...	....	....	....	....
"	...	57.80	0.63	....	6.37	35.10	....	...	0.10	0.06	....	....	....	....
California	....	53.50	2.60	....	0.50	43.40	...	....	....	...	...	...	....	....
New South Wales	....	58.13	3.04	....	5.22	33.46	.	....	....	0.15	....	....	....	....

ANALYSES OF PLATINIRIDIUM.

	Pt.	Ir.	Rd.	Pd.	Ru.	Os.	Au.	Osmiridium.	Fe.	Cu.	Sand.	Pb.	Fe_2O_3	CuO.
Russia	19.65	76.80	....	0.89	...	....	....	...	...	1.78	....	....	....	....
Brazil	55.44	27.79	6.68	0.49	....	trace	....	...	4.14	3.30	..	....	....	..

ANALYSIS OF SPERRYLITE.

Canada, Pt. 52.57%; Rd. 0.72%; Sb. 0.50%; As. 40.98%; Fe. 0.07%; SnO_2 4.62%.

* *Am. Jour. of E. Science* 37, p. 67, 1889.

† Mr. J. T. Donald of Montreal informs me that a Newark, N. J., refiner (Baker & Co.?) of platinum has successfully smelted a quantity of sperrylite and made wire from it, which demonstrates that there is no difficulty in working this mineral if it be found in sufficient quantity.

‡ *Am. Jour. of Science*, V., 21, 123, 1881.

Geology.—The genesis of native platinum is not well understood. In but few places is its occurrence *in situ* known, and in these the amount of platinum found is extremely small. The chemist Vauquelin reported having found it in the argentiferous *fahlerz* of Guadalcañal, Spain, and Major Pond reports its occurrence in New Zealand in a quartz vein, but unfortunately neither of these statements has been verified by subsequent observers, and the theory of deposition from solution based upon them is rendered still more doubtful by the known insolubility of the metal. The undoubted occurrences of platinum *in situ* are in Russia, Brazil, New South Wales, Canada, and Colombia. In the Urals, Russia, it is found in serpentine and peridote, and as the metal occurs in the greatest quantity where the deposits rest upon a serpentine formation, it is believed that the metal is derived from that rock. At Tagilsk and Biserk the platiniferous area is completely bounded by serpentine rocks, while in California the placers containing platinum are always in close proximity to serpentine, although the metal has not yet been found in it.

In Brazil platinum is found associated with gold and palladium in quartz and *jacutinga*, but these are to be classed as metamorphic sedimentary deposits. The so-called auriferous veins of Brazil have been described by a number of writers as being *interstratified* with granite, gneiss, talcose and mica schists, and clay slates, the quartz frequently occurring as lenticular masses in the slate.* Besides these occurrences, palladium is found alloyed with gold in the granite of Condonga. The gneiss is the oldest stratified rock of Brazil, and is said to correspond to the Canadian Laurentian, the slates being assigned to the Lower Silurian. According to Hartt, the clay slates and associated quartzites strongly resemble the gold-bearing rocks of Nova Scotia, while the Minas Geraes formation is similar to that of the Southern Atlantic States in which itacolumite occurs.

In New South Wales the platinum occurs at Broken Hill, disseminated in felsite and granite, both metamorphic rocks of unknown age. The beach sands of the Richmond and Tweed rivers are the detrital remains of metamorphic rocks, serpentine being the most common.

In Ontario, Canada, the occurrence of platinum in the nickel ores of Sudbury is unique, not only because of its combination with arsenic in the mineral sperrylite, but also by reason of its occurrence in the nickel sulphide. As yet sperrylite has been identified only in the alluvial sands produced by the erosion of the nickeliferous strata, but there is reason to believe that the same compound exists in veins. Mr. S. H. Emmens informs me that, according to Dr. Robert Bell, "the vein of the Vermilion mine occurs in diorite and is about four feet wide, but without distinct walls or any veinstone except a mixture of the country rock." According to Mr. Emmens, platinum has been found in the MacDonnell mine, which is in Denison Township, Ontario. According to a report made by Ricketts & Banks, "the vein filling is largely a changed diorite with some little quartz and feldspar, carrying several irregular bunches of chalcopyrite and pyrrhotite with admixture of nickel minerals. The ore seam where thin has a shaly diorite filling." Mr. Emmens himself describes this "shaly diorite" as a graphitic schist.

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* Burton, *The Highlands of Brazil.* Castelnau, *Expédition dans l'Amérique de Sud.* Von Eschwege, *Geognostisches Gemälde von Brazilien.* Hartt, *Geology of Brazil.* Williamson, *Geology of the Parahyba Gold Region.*

Mr. F. P. Dewey of Washington, who made the analyses, found from a trace to 0.53 oz. of platinum in the vein matter of this mine.

These analyses agree with those previously made by Mr. F. W. Clarke * of certain nickel ores from the Canadian Copper Company of Sudbury. More recently, Mr. Emmens has found platinum in the "nickel oxide" manufactured by the Orford Copper Company from the matte of the Canadian Copper Company prepared from the ores of Copper Cliff, near Sudbury. An average sample of 18 tons of this oxide showed 0.25 oz. Pt.

The platinum deposits of Colombia may be divided into four classes, viz., river bars, river banks, gravel deposits, and *caliche* beds.† Geologically they are divided into recent river deposits, gravel deposits, and *caliche* deposits. In El Choco, Colombia, the word *caliche* is used to define those deposits which consist of clay, sand, and boulders indiscriminately mixed, and which show no stratification, according either to the specific gravity of the materials or to their size. The banks when complete show clays of four colors, viz., blue, red, white, and yellow, in the order named, beginning at the bottom. At times the white and yellow strata are missing, less frequently the red is wanting, but the blue is always present. These deposits are the oldest of the platiniferous alluvials of El Choco and were formed by glaciers. The underlying rock is either a dark slate-blue indurated clay or a pudding-stone conglomerate. They are frequently found interstratified, and sometimes they pass one into the other by insensible gradations. These clays and conglomerates are similar to those of the Atlantic coast between the Orinoco and Rio, and, like them, are probably of Tertiary age, but this cannot be determined with certainty, as all fossil remains have been obliterated. Away from the coast they were tilted by the upheaval of the Andes which took place during the middle or toward the end of the Tertiary period. This upheaval was followed by the glaciation which I believe formed the *caliche* beds. The reasons for believing them to be of drift origin are as follows: First, none of the *caliche* deposits which I have had the opportunity of examining belong to any present or past river system; they are always high above the river, forming a plain the slope of which is frequently across the slope of the river valley. Secondly, they do not extend along an old valley or slope, but across hills and valleys indifferently. Thirdly, there is no stratification in the deposit other than that of color, the clay, sand, gravel, and boulders being indiscriminately mixed. Lastly, high in the hills above the deposit, yet in line with them, isolated boulders are found which are clearly of drift origin. These boulders, which are flattened below and rounded above, probably from weathering, are totally different from the surrounding outcropping rocks, and are far from any stream which could have moved them. Although glacial striæ are rare, owing to the weathering of the outcropping rocks, I have found what I considered to be such. The chief among these deposits, not only for its size and continuity, but also for its richness in gold and platinum, is that known as the Minas de Condoto.

Opposed to this theory of formation are the stratification of color and the roundness of the boulders in the clays. The different colors of the clays probably depend upon the different states of oxidation of the iron contained in them. The

* Clarke, *Bulletin* 64, *U. S. Geological Survey.*

† Bullman, *Engineering and Mining Journal*, April 2, 1892.

greater part of the boulders in the blue strata consist of diorite, the fine sand consisting of magnetite topaz, garnets, epidote, chromite, and cubes of pyrites. In the red and white strata the boulders consist principally of granite. But few pyrites are found in the white stratum, and none in the red, the color of the latter being due to sesquioxide of iron. In the top stratum but little sand of any kind is found, although the platinum and gold are frequently found as abundantly in it as in the strata below. Occasional pieces of quartz are its distinguishing characteristic.

The roundness of the boulders is partially due to disintegration in place, as many boulders which appear square or of irregular shape in the *face* leave a rounded boulder upon washing. This is particularly true of the boulders of the red stratum.

The true gravel deposits of El Choco, which are of later formation than the *caliche* and derived in part from them, are old river beds. The largest deposits of this kind are situated along the Tamaná, Iró, and San Juan rivers. The main body of the Tamaná bed is three miles distant from the present river and separated from it by a range of hills. The Iró deposit stretches uninterruptedly from the present river to the divide of the San Juan River. This deposit is from 6 to 20 ft. deep and has been extensively worked by the natives. The river bar and bank deposits are still being formed from materials brought from the hills, or from changes in the course of the rivers.

From the frequent occurrence of diorite boulders in the *caliche* of El Choco it would seem probable that the platinum will eventually be found disseminated in this rock. During my last visit to these mines I succeeded in obtaining a nugget weighing 53.5 grams having a specific gravity of 13.58, a large part of which consisted of chromic iron, and this is said to be the only specimen of its kind ever found in the country. As chromic iron is usually associated with serpentine, it is possible that in Colombia, as in Russia, this rock furnishes the metal. On a small tributary of the Condoto River there is an outcrop of micaceous schist in which are numerous segregated veins of ferruginous quartz, seldom over two inches in thickness or more than three or four feet long. The quartz is quite soft to a depth of two feet, and is easily scraped out to be washed in *bateas*. It frequently yields gold, and sometimes, it is said, platinum. All of these occurrences indicate that the platinum of El Choco is a constituent of metamorphic rocks and not of mineralized veins, and this assumption is strengthened by the occurrence of platinum in place in Antioquia, which adjoins El Choco on the northeast. In 1826 Boussingault found near Santa Rosa small rounded grains of platinum with gold in the oxide of iron, quartz and clay filling small veins in an altered syenite. He also mentions that toward El Choco the syenite changes into diorite, and suggests that this rock may be the source of the metal found in that locality.*

In British Columbia it would appear that the alluvial platinum has resulted from the erosion of diorite. In regard to the Tulameen deposits, Mr. George Dawson, in Part R of the *Geological Survey of Canada*, 1887, says that "while there is a notable abundance of greenish chloritic and hornblendic schists and diabasic rocks, and while chromite and magnetite are found associated with the platinum and gold, no peridote or serpentine is actually known to exist." He

* Boussingault, *Viajes Cientificos* and *Ann. Chem. et Phys.*, 32, 1826.

further says that the appearances indicate that the platinum was derived from a large mass of intrusive diorite occurring in the vicinity.

Mining.—The following description of the method of platinum mining in Russia, the only country in which the metal is mined for itself alone, is in part furnished by Mr. George F. Kunz, gem expert of Tiffany & Co., New York, who has lately returned from a visit to the mines of Prince Demidoff. The platinum-bearing sand is found at a depth varying from 6 to 40 ft., the "pay streak," which is from 6 to 10 in. thick, resting directly upon a serpentine bed-rock. When the overlying gravel is not too thick it is thrown to one side and the "pay sand" then scraped up; but, as a rule, shafts are sunk to the bed-rock and the sand removed by drifting. This work is done during the winter months, the sand being piled to be washed during the summer. The sand to be washed is carted upon an elevated platform, from which it is fed with water into a revolving conical screen, the platinum and fine sand passing through into the sluice below, while the coarse materials are discharged at one side and carted away. The sluice consists of two compartments, an outer and an inner one, the latter being kept locked and opened only once every 24 hours by a government inspector. The tailings from the first compartment, in which most of the platinum settles, enter the second, where they are puddled and raked by women, the coarse part being thrown to one side to be carted away, while the fine sand passes into a tail sluice. The machines run continuously, are driven by steam and attended to by men and women working in shifts of 12 hours each with a rest of 4 hours.

According to information furnished to Mr. Kunz by Mr. Gramatchikoff, the superintendent of the Demidoff mines, each of the three machines on the estate has a capacity of about 400 metric tons of sand per 24 hours, yielding 2.66 kilos of metal, or a total daily output of 7.98 kilos.

During the summer months from 3000 to 3500 men and women are employed; during the winter but 1000. According to the same authority, the wagon-drivers receive about 90c. per day for their labor and use of horse and cart. Most of the washing is performed by women, who are paid about 30c. per day. The men earn about 55c. The cost of washing at the Demidoff mines is as follows: 40 carts and drivers at 90c., $36; 16 men at 55c., $8.80; 4 women at 30c., $1.20—total per machine per day, $46. This estimate does not include cost of fuel, engineer, shovelers, interest, depreciation, etc.

As the present output of one machine is 2.66 kilos, the output of the three machines for 180 days would, on the same ratio, be 1436.4 kilos, which would make the cost of washing about $16.85 per kilo of native metal, or $0.041 per metric ton of sand washed. This is extremely small, even considering the lowness of the wages paid. According to Mr. Gramatchikoff, sand containing less than three grams per ton cannot be profitably worked, although a few instances of sand containing only 2.5 grams per ton and worked at a profit can be cited. These costs relate only to the Demidoff estate, but they probably do not vary much from those of the northern or Government district. In the Goro-Blagodat district the Government has granted 70 concessions, and the output is considerably larger than in the southern district. All the platinum produced pays a tax of three per cent, in kind, to the Government.

The average yield of the Demidoff estate during 1891 was, according to the

figures of Mr. Kunz, 6.55 grams per metric ton. The report of the Russian Department of Mines, 1892, states that during 1890 the total amount of platiniferous sand washed in the empire was 773,153 tons, yielding 2836 kilos of platinum, an average of 3.8 grams per metric ton, the industry employing 5853 men. The depth at which the pay sand was found varied from 2 to 42 ft. According to the same authority, there was mined and washed on the Demidoff estate during that year 283,200 tons, yielding 865.7 kilos, being an average of 3.06 grams per ton.

In Colombia platinum is generally mined in connection with gold by very simple methods. *Caliche* and gravel deposits are ground-sluiced, the water being supplied by pits or *pilas* excavated near the working face and filled, as a rule, by direct rainfall. The sluice is occasionally cut in the bed-rock, but generally it is in the blue clay and rapidly deepens with wear. The tools used are the bar, of which one end is three inches broad and the other pointed; the *almocafre,* a sickle-shaped iron tool used in raking the gravel in the sluice; *cachos,* used in removing gravel from the sluice; and finally the *batea,* or wooden bowl, in which the sand concentrated in the sluice is washed. This work, in which all the members of a family take part, seldom begins before nine o'clock, and is performed as follows: After the water is turned on, the man cuts down the clay with his bar and the pieces roll into the sluice, where they are broken up by the women and children, who wash the larger stones and throw them to one side. In cleaning up, the miner begins at the tail end and loosens the material to a depth of six inches; it is then roughly raked back and forth by the women with an *almocafre.* The large gravel is thrown aside, while the clay runs off and the sand settles. This operation is repeated several times until finally nothing but sand, gold, and platinum are left. This is scraped out and washed in *bateas.* The gold and platinum are placed on a porcelain plate and separated by gently and regularly tapping on the edge.

River bars and beds are generally worked by women, who dive for the fine black sand and wash it in *bateas.* In working river banks, the covering of loam is ground-sluiced, the pay streak of sand is then collected and washed in the usual way.* A large output cannot be expected from such methods, yet in 1890 not less than 125 kilos of platinum and an equal amount of gold were obtained from the San Juan platiniferous placers. This amount might be largely increased, as several of the *caliche* deposits offer good facilities for hydraulic working on a large scale, and it is probable that in the near future they will be so worked.

The river beds would also yield large amounts of the metal if worked in a systematic way, as the natives can work only when the water is very low, which does not occur for more than 10 or 15 days in the year. Mr. Vincente Restrepo, in his book, the *Gold and Silver Mines of Colombia,* quoting Mr. Robert White, who in 1879-80 examined the El Choco district for the Government, says: "In the upper part of the San Juan and Tamaná rivers I found that the heavy sand contained nearly an ounce of gold to the ton;" also, "the stratum or bed (of sand) that rests upon the rock produces by careful washing 10 oz. of gold to the square yard." While I would hesitate to confirm this report, it is certain that the head waters of these and other rivers in the district are rich in both gold and

* Bullman, *Engineering and Mining Journal*, April 2 and May 14, 1892.

platinum. The *caliche* deposits, of which I have examined nearly all, average from 0.5 to 1 gram per cubic meter. The proportion of gold to platinum varies in different localities, but would probably average 1:1.

In the United States platinum and iridosmine are obtained as incidental products in the gold washings of California and Oregon, chiefly from beach sands. In British Columbia the production of platinum has also been, until quite recently, incidental to the yield of gold. Now, however, a company has been formed, and will soon commence work hydraulicking the placers of the Tulameen River.

Mr. J. T. Donald of Montreal has courteously furnished me with the following data taken from the report of a mining engineer who examined the Tulameen property during July, 1892, in the interests of an English company: "No. 1 Bench yields 4 grams of platinum per cubic yard, also a few colors of gold. No. 2 Bench yields 1 gram of gold per cubic yard and 0.55 gram of platinum. No. 3 Bench yields 0.4 gram of gold and platinum per cubic yard, both metals being very fine."

Mr. Donald states that the yield of the first "clean-up" was not so good as the tests given above, being only eight cents per cubic yard, three fourths being platinum.

In the West, and I presume in British Columbia as well, too little attention has hitherto been paid to the recovery of platinum, but it is certain that these localities can produce important quantities of the metal. When it is proved that platinum is associated in appreciable quantity with the gold, the sluice-dirt should be run off more slowly during the clean-up, and an effort made to concentrate the black sand. If this sand contains less than 7 grams of platinum to the ton, it might with advantage be run through a small auxiliary sluice, set with a grade of 8 to 12 in. in 16 ft. according to the size of the grains of metal. The sand obtained from the second washing can be concentrated and brought into merchantable shape by Frue vanners or end-shake belt machines. Concentration by Frue vanners has already been tried in New South Wales on the Broken Hill ore, but Dr. Mingaye reports the experiment to have been commercially unsuccessful, which was probably due to the small quantity of metal contained in the ore. The *Report of the New South Wales Department of Mines* for 1891 says that the ore operated upon was a ferruginous felsite containing by analysis 2.78 grams of platinum per ton. Two experiments on ton lots gave concentrates containing 15.16 and 28.08 grams, respectively.

In conclusion it may be said that when placer dirt contains 0.075 to 0.100 gram per cubic meter, it will pay to collect and re-work the sluice-box sand.

Metallurgy.—While much has been written about the metallurgy of platinum, but little is known in regard to the commercial processes used for its extraction and refining. Long experience has enabled the firms refining platinum to introduce modifications of the old processes which have simplified and cheapened the work. Such improvements are kept as trade secrets, but otherwise the processes used are either those of Wollaston, as modified by Johnson, Matthey & Co., Heraeus and others, or the fusion method of Deville and Debray. Chief among the earlier experimenters in the production of malleable platinum were Count Van Sickengen, who succeeded in preparing foil and wire in 1772, and Achard, who made the first platinum crucible in 1784. Achard's method, fusing

with arsenic and finally driving this off by ignition, was used for a number of years by Janetty of Paris. The next important step in advance was made by Knight, who discovered, in 1800, a method of obtaining workable platinum from the double ammonium chloride. The same discovery was made about the same time by one of the founders of the well-known firm of Johnson, Matthey & Co. This discovery, which was a method of obtaining platinum sponge in a coherent form, was afterward elaborated by Prof. Wollaston, who made it the subject of his Bakerian lecture in 1828.*

By Wollaston's method the crude ore is dissolved in aqua regia, and the platinum precipitated by ammonium chloride as the double chloride, which is then gently heated, great care being taken not to cake the sponge. The finely divided sponge is rubbed fine until it will pass through a fine lawn sieve. After levigation, the pulp is pressed cold into a mold, then further pressed by the aid of a powerful lever until the cake is perfectly coherent. This cake, after a thorough drying, is heated to a white heat and forged; the ingot obtained in this manner can be drawn and rolled. This process was used by refiners until 1859, in which year St. Claire Deville and Henri Debray succeeded in melting platinum on a large scale by the use of the oxyhydrogen blowpipe, an application of the latter which had been proposed some years before by Dr. Hare of Philadelphia, who by its use first melted the metal on a large scale.

The researches of Deville and Debray, which are among the classics of chemistry, were published in the *Annales de Chimie et Physique*, vols. lvi. and lxi. They give methods for the revivification of scrap, for the preparation of the pure metal, and for a platinum-iridium-rhodium alloy, direct from the ore. By their method, as modified by Matthey, crude metal is treated in a reverberatory furnace with an equal weight of galena. When the platinum has formed an alloy with the lead, reduced by the iron in the ore, ground glass and borax are added as fluxes. The osmiridium does not alloy with lead, and gradually settles to the bottom by virtue of its high specific gravity. The sulphur is then oxidized by the addition of litharge. Finally the slag is skimmed off, and the metal run into ingots, which upon cupellation yields platinum containing some iridium and rhodium. To purify this it is melted with six times its weight of chemically pure lead, which is then granulated and treated with nitric acid diluted with eight parts of water. Part of the lead and the copper, iron, palladium, and rhodium are dissolved, leaving a black amorphous powder containing platinum, lead, and small quantities of the other metals present; the iridium existing as a brilliant crystalline substance insoluble in nitric acid. This residue is treated with dilute aqua regia, which dissolves all the platinum and lead, but not the iridium. The solution of the chloride is evaporated to a small bulk, and sulphuric acid added to precipitate the lead. To the filtrate ammonium and sodium chlorides are added, precipitating the platinum as ammonium-platinum chloride. The whole is heated to 80° C. and left to stand for some days. The sodium chloride is added because the double chloride is more insoluble in a solution of it than in a menstruum of ammonium chloride. The rhodium present remains in solution as a double salt. When the precipitate has completely settled it is

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* *Phil. Trans.*, 1829.

washed repeatedly with a solution of ammonium chloride and finally with water. As some rhodium may still be present, the chloride is dried and mixed with potassium bisulphate containing a small quantity of ammonium sulphate, and the whole is then heated in a platinum dish until the platinum is completely reduced. The rhodium remains as a bisulphate which can be removed by water, leaving behind pure platinum sponge, which is melted in a lime-furnace to be described later. This is the process of purification adopted by Johnson, Matthey & Co. in preparing the pure platinum used by them and the French Government in the preparation of standard weights and measures.

For ordinary uses, where small quantities of iridium and rhodium do no harm, but, on the contrary, add to the insolubility and resistance of the platinum, this refining is not done, the cupelled metal being simply melted and run into ingots. According to Deville and Debray, the cost of preparing these ingots is 1.01 francs (a franc = 19.3 cents) per kilogram of ore treated when working on 100-kilogram lots.

For the preparation of a purer metal than that obtained by direct fusion, Wollaston's method is still used in a modified form by Heraeus of Hanau, Germany, who treats the crude metal with dilute aqua regia (1:2) under a pressure of 12 m. of water, it having been discovered that solution takes place quicker and with a less quantity of acid when pressure is applied. The solution is evaporated to dryness, and the mass then heated for some time at 125° C., at which temperature the chlorides of palladium and rhodium are reduced to *ous* salts. The mass is dissolved in water and the platinum precipitated by ammonium chloride: after washing and drying it is ignited, the sponge collected, pressed, and finally melted in a lime crucible. Still another modification of the Wollaston method is given by Dr. Pirngruber in the *Engineering and Mining Journal,* Oct. 8, 1887. The principal points of difference consist in boiling the solution obtained by aqua regia with caustic soda, cold alcohol being added to neutralize the excess of alkali. After acidulation with hydrochloric acid, the platinum is precipitated by potassium chloride, which is reduced and fused in the usual manner.* This modification is not, so far as I know, used by any firm producing platinum in quantity.

The lime-furnace used in the melting and refining of either platinum sponge or cupelled platinum is the invention of Messrs. Deville and Debray, and consists of two cylindrical pieces of quicklime hollowed out to receive the charge of metal, then fitted together, and the whole encircled by bands of iron. The roof is slightly arched, and has a conical opening through which is passed the tube by which the fuel is introduced. The hearth is flat and the sides are curved to meet the arch above. It should be of such a width that the melted metal will have a thickness not exceeding three to four millimeters, and in the lower part is provided with a lip which serves as a vent for the flame and as a tap-hole for the metal. The fuel used is illuminating gas mixed with oxygen in order to obtain the highest possible temperature. Hydrogen was formerly used instead of illuminating gas, but, although giving a greater heat than the latter, its use has been abandoned on account of its greater cost. In this furnace the platinum is both

* *Vide* comment by Dr. Wyatt, *Engineering and Mining Journal*, Oct. 15, 1887.

melted and refined, any iron or silicon present being absorbed by the lime, while osmium, if present, is volatilized as oxide. The crucible can be made of any size, as much as 250 kilos having been melted at one fusion. In melting large quantities which are to be cast, the lime should be inclosed in an iron box swung on trunnions for convenience in pouring.*

The metallurgical treatment of platinum is not without considerable danger to the inexperienced operator. The volatile osmic acid is an irritant poison acting especially upon the mucous membranes. If its vapor comes in contact with the eye, it produces partial or even total blindness.

In former years the oxygen used in fusing was prepared from potassium chlorate, but at present oxygen can be bought in cylinders from a number of companies. In summarizing, it may be said that the method adopted in the manufacture of platinum depends upon the nature of the ore, the quantity to be treated, and the use to which the refined metal is to be put. The lead-fusion method is the cheapest and is used when a pure metal is not required; but if the ore contains a large percentage of iridium and rhodium, the process can only be used in a modified form. If a pure, soft metal be required, it is better to use the Matthey or Heraeus modification of Wollaston's wet method. Mylius and Förster, the latest experimenters on platinum, state that they found the metal produced by Heraeus in the wet way to be the purest in the market. They give the following analyses of commercial and pure platinum:

	Pt.	Ir.	Rd.	Pd.	Ru.	Fe.	Cu.	Ag.
Platinum crucible	96.90%	2.56%	0.20%	tr	0.02%	0.20%	.....	.....
Purified platinum, maker unknown	99.29	0.32	0.13	....	0.04	0.06	0 07	....
Pure platinum, Johnson, Matthey & Co.	99.9+	....	0.01	.....	.....	.....	.....	0.01
Pure platinum, Heraeus	99.9+	tr	....	.....	.....	0.001	.....	....

The exact cost of preparing platinum in the wet way is not obtainable, but it is much higher than by the lead-fusion method. Deville and Debray state that the cost of purifying scrap platinum in the wet way was in 1859 about 250 francs ($50) per kilogram, being about 25% of its then value; but it is undoubtedly much cheaper than this at the present time. A platinum refiner informs me that in working on an ore yielding 80% platinum, he allows $1 per Troy ounce of fine metal ($32 per kilo) for the cost of preparing sponge and melting into ingots. This, however, is more than the actual cost, for no allowance was made for the value of the "residues," or for the platinum recovered from the old melting crucibles. Moreover, as this work was done on a comparatively small scale, it is reasonable to assume that the cost would be higher than that for ore treated in quantity; in fact, I am informed that Johnson, Matthey & Co. offered some time ago to receive ore (80% Pt), and return fine metal at a charge of $35 per 100 oz. Troy, which is at the rate of $11.20 per kilogram.†

Physical and Chemical Properties.—Pure platinum has a tin-white color, is soft, has a specific gravity of 21.5 at 17.6° C., is extremely ductile, and next to gold and silver is the most malleable metal known. It can be welded at a white heat,

* For a full description of these furnaces and the manner of fusing the platinum, see *Ann. Chim. et Phys.*, vols. lvi. and lxi.

† Since the above was written I have been informed by good authority that platinum cannot be prepared at 35 cents per oz. One refiner, to whom the statement was submitted, said: "It is possible under very favorable circumstances that platinum might be produced for $35 per 100 oz., but there would be no profit in it." Another refiner said that platinum cannot be produced at less than 60 cents per oz.

and soldered by means of platinum arsenide. An extremely fine wire can be fused in a Bunsen burner, but in quantity it is infusible in the greatest heat of a blast-furnace. Violle, a recent experimenter, places its fusing point at 1750° C. It is curiously related to silver and palladium by its property of spitting when cooled. Its specific heat increases with the temperature, and is equal to $0.0317+0.000006t°$.

Platinum, whether fused, hammered, or in sponge, has the property of absorbing or occluding hydrogen, which, in the presence of oxygen, unites with it to form water. Döbereiner's hydrogen lamp was constructed on this principle. The metal does not occlude oxygen, but condenses it upon its surface. Spongy platinum, which has a large surface in comparison with its bulk, condenses large quantities of oxygen, and is consequently often used as an oxidizing agent. Platinum black possesses this property to a still higher degree than the sponge, being capable of condensing 800 times its bulk of oxygen.

Platinum belongs to the isometric system and crystallizes in octahedra. Very minute crystals can be obtained by passing a current of electricity through a piece of foil upon which very fine topaz-dust has been sprinkled.

Platinum is one of the most permanent metals known, being unattackable by oxygen or water, or by nitric, hydrochloric, or sulphuric acid at any temperature. It is not blackened by sulphur. It is, however, attacked by caustic alkalies and alkaline cyanides; and consequently these should never be fused in a platinum vessel. The same restriction applies to potassium nitrate. The metal completely dissolves in aqua regia, forming a tetrachloride, which is largely used in chemical laboratories in the determination of potassium and ammonium. Platinum combines with carbon, silicon, phosphorus, and arsenic. Carbide of platinum is produced when a platinum crucible is heated by a smoky Bunsen burner. Crucibles are frequently ruined in this way, as the carbide blisters the metal. Platinum-silicon can be prepared by heating equal weights of sponge and silicon in a carbon crucible. When this substance is a constituent of commercial platinum, it makes the latter very brittle. Finally, platinum is reduced from its solutions by nearly all metals.

Uses.—The first use to which platinum was put was, in all probability, the adulteration of gold, it having been found that a considerable quantity of the white metal could be alloyed with the yellow without changing the color of the latter. That counterfeiting of this kind must have been extensively practiced is made evident by the chemists Baumé and Macquer, who, in a note communicated to the Paris Academy in 1758, state that platinum is scarce because the Spanish Government has prohibited its exportation on account of its being used to falsify gold. Later on the Spanish Government debased its own coin in this manner.

The first legitimate use of the metal was the heating of substances on foil or in crucibles made of it. As soon as Achard made his first crucible, the value of his invention was promptly recognized by chemists, and Janetty of Paris commenced, and became celebrated for, their manufacture, although his prices were so high that his crucibles were beyond the reach of many.

The demand for platinum for crucibles and other purposes greatly increased when Wollaston perfected his cheaper process of preparation, and Liebig voiced the general sentiment of chemists when he wrote in his *Letters on Chemistry*, "Without platinum, it would be impossible in many cases to make the analysis of

a mineral. . . . Without platinum, the composition of most minerals would have yet remained unknown." Since that time its field of usefulness has been constantly widening, though its use in coinage, for which its malleability, unalterability, and high intrinsic value adapt it, has been abandoned. The Russian Government early recognized its suitability for that purpose, and, a large quantity of the metal having accumulated at the Imperial Mint, commenced its coinage in 1828. The pieces issued were of 3, 6, and 12 rubles, of the par value of $2.40, $4.80, and $9.60. The 3-ruble pieces weighed 10.36 grams, which would make the gram of platinum worth about 23c. About 14,250 kilos were coined up to 1845, when, owing to the increased value of the metal, the pieces were extensively exported, and the Government called in the coins issued, by an imperial ukase dated June 22, 1845. These coins contained about 2% of iridium. At present the United States uses more platinum than any other country, owing chiefly to the great development of the dental and electrical industries, which annually consume an amount almost equal to 50% of the world's product. The chief dental use of platinum is for the manufacture of the pins by which artificial teeth are attached to the plate. Platinum is the only metal that will serve for this purpose and stand the high heat at which the teeth are baked. The pins vary in size according to the size and quality of the teeth. Some weigh as much as 0.39 gram each, while those for the better quality of teeth run about 0.05 to 0.06 gram; in cheap teeth still smaller pins are used. Formerly a considerable quantity of platinum was used for plates for teeth, but at present vulcanized rubber has almost entirely superseded it for this purpose.

From returns received by various dental companies in the United States, it is estimated that 1088.65 kilos, or 35,000 oz. Troy, are annually worked up in this industry, and that the annual rate of increase is about 2½%. In England the dental trade annually uses about 775.6 kilos, or 25,000 oz., but the consumption for this purpose in other countries is insignificant.

Platinum is used, on account of its infusibility and the fact that its coefficient of expansion is nearly the same as that of glass, to connect the outside copper wire with the carbon filament of incandescent electric lamps. This use has grown to vast proportions within the last ten years, notwithstanding the fact that the length and thickness of the wire used have steadily decreased. In 1880 the wires used were Nos. 20 and 22, Brown & Sharp gauge, .031 and .025 inch thick; at present Nos. 28 and 30 Brown & Sharp gauge wires, .012 and .010 inch in diameter, are used and give equally good results. In 1888 the wire used per lamp by the Sawyer-Man Company weighed 0.130 gram; that by the Edison Company 0.065 gram. At present the latter company uses but 0.007 gram of platinum per lamp. The new Sawyer-Man lamp contains no platinum at all, the carbon filament being connected direct with an iron wire. The lamps are made of separable parts, and the carbon is protected by an attenuated atmosphere of nitrogen. Mr. Hebbard, President of the Sawyer-Man Company, thinks that the amount of platinum used in electric lighting will, from now on, rapidly decrease.

From returns received from various electrical companies it is estimated that 1172.8 kilos, or 38,000 oz. Troy, are annually used in the electrical industries of the United States. It has not been possible from the figures furnished to divide this total according to the different uses, but it is certain that the greatest part is

used in the manufacture of incandescent lamps, though a considerable amount is also used in the manufacture of the contact points of telegraph-keys.

The amount of platinum annually used in the construction of stills or retorts for the concentration of crude sulphuric acid is about 279.9 kilos, or 9000 oz. A still contains from 24.7 to 46.3 kilos of platinum and has an average life of one year. In the construction of these stills a pure platinum is not desirable, a three per cent iridium alloy being generally preferred.* A prominent European refiner estimates the platinum used throughout the world in the construction of stills, retorts, etc., for the concentration of sulphuric acid, at 2480 kilos annually, of which amount 50% is new metal, the rest being made up of old stills and other scrap. The use of platinum crucibles, dishes, filtering cones, spoons, and wire in chemical analysis is too well known to need comment. The amount so used in 1891 was approximately 92.6 kilos; besides this, about 12.3 kilos were used by chemists in the shape of platinic chloride.

Platinum has been employed quite extensively in jewelry, but at present it seems no longer fashionable, and the amount used for this purpose shows a decided decrease. From returns furnished by several firms using the metal, it is estimated that 49.4 kilos were consumed in this industry in 1891, and about the same amount in 1892. Messrs. Tiffany & Co. of Union Square, New York, have informed me through Mr. G. F. Kunz that they used $4000 worth of platinum in 1891 and a like amount in 1890.

Among the minor uses of platinum may be mentioned the manufacture of platinum-print paper for photography; its use by balance-makers for weights, etc.; for surgical and philosophical instruments of precision; for pointing stylographic pens; for the balance-wheels and hair-springs of non-magnetic watches; for obtaining a silver color on porcelain; for platinum plating, "oxidizing" silver, and for the fuses of electrically exploded dynamite cartridges.

The amount of platinic chloride used in oxidizing silver is increasing annually, the black produced being found more durable than that obtained by alkaline sulphide solutions; it also takes a very brilliant polish. The Gorham Manufacturing Company informs me that it used 1 kilo of platinic chloride in 1890 and 1.6 kilos in 1891 for this purpose.

The following table shows the amount of platinum worked up and used in the United States by the different industries during the year 1891. It also shows how much was new by importation, and how much was old or scrap metal.

CONSUMPTION OF PLATINUM IN THE UNITED STATES IN 1891.

Use.	Total Amount, Kilos.	Newly Imported Metal, Kilos.	Scrap, Kilos.	Use.	Total Amount, Kilos.	Newly Imported Metal, Kilos.	Scrap, Kilos.
Electrical	1172.8	586.4	586.4	Ceramic art	6.8	.....	6.8
Dental	1088.6	750.0	338.6	Stylographic pens	2.3	2.3	.....
Stills, retorts	279.9	279 9	.....	Electric fuses	2.5	2.5	.....
Crucibles, dishes, etc.	92.6	70.0	22.6	Non-magnetic watches	1.0	1.0	.....
Jewelry	49.4	49.4	.....	Platinum plating, Surgical instruments, Philosophical instruments	10 0	3.0	7.0
Photography	18.5	18.5	.....				
Platinic chloride	12.3	.....	12.3				
Balance-makers	9.2	9.2	.....	Oxidizing silver	4.7	.....	4.7

* For details of the construction and use of platinum stills, see Lunge, *Manufacture of Sulphuric Acid*, and Scheurer-Kestner, *Bull. Soc. Chim.*, xxiv. p. 501, and xxx. p. 28.

Production.—Russia annually produces more platinum than all the other countries of the world. The platiniferous area is large, and as yet the yield has shown no sign of diminution, but on the contrary it may be said that an increased yield has quickly responded to an increased demand. Still it is reported, on excellent authority, that the output is at its maximum and will shortly show a falling off. For the years 1824 to 1862 the annual production and value thereof is not obtainable, but Phillips, in *Ore Deposits*, gives the output for the period as 41,967 kilograms. Since 1862 the annual production has been as follows:

Year.	Weight, Kilos.	Year.	Weight, Kilos.	Year.	Weight, Kilos.	Year.	Weight, Kilos.
1861......	....	1869......	....	1877......	1724.3	1885.....	2591.0
1862.....	2325.9	1870......	1756.3	1878......	2066.3	1886......	4316.0
1863......	492.2	1871.....	1861.7	1879......	2260.3	1887......	4407.0
1864......	436.3	1872......	1381.8	1880......	2947.0	1888......	2716.7
1865......	2273.2	1873......	1430.0	1881......	2985.1	1889......	2634.8
1866	... ...	1874......	2010.6	1882......	4084.0	1890......	2833.7
1867......	1766.9	1875......	1541.1	1883	3534.9	1891......	4226.0
1868......	1622.7	1876......	1573.8	1884......	2236.6	....	....

The figures given for the years 1874 to 1890 are official, being derived from the reports of the Russian Department of Mines; those for the years 1862 to 1867, from Roscoe & Schorlemmer; and those from 1868 to 1874, from the *Engineering and Mining Journal.* The total production from 1824 to 1891 has been, according to the above figures, 113,207.7 kilos. There is good reason for believing that this amount as reported by the Government is far below that actually produced; for though the tax is only three per cent, payable in kind, it is certain that large amounts of the metal are annually exported from Russia of which no returns are made. It is probable that much of this smuggled platinum is stolen at the mines; and I am informed by an excellent authority that the amount of metal taken secretly out of Russia amounts to from 35% to 40% of the annual production as officially stated. The same authority gives the production for 1891 as from 6142 to 6282 kilograms.

No official return of the production of Colombia has ever been made. The metal pays no export tax, and no custom-house record of its exportation is kept; nor has the Government ever published any official statement of the mineral production of the country. From its discovery down to 1778 but little attention was paid to this metal, the miners, according to Don Vicente Restrepo, throwing it away as useless. In the latter year the Spanish Government ordered all the platinum found to be sent to the Royal Treasury, but as nothing was paid for it, little was sent. Ten years later the Royal Mint offered $4.40 per kilo for it, and it is said that 1943 kilos were extracted in 1788. About this time English merchants at Cartagena began buying it in large quantities, paying about $25 per kilo. Humboldt, who traveled in Colombia during 1819–20, estimated the annual production at 545 kilos, which was worth at the mines about $17 per kilo, its value in Paris being from $55 to $65. Cochrane, who was at the mines during 1824, estimated the production at 500 kilos per annum. Since then the production has greatly fallen off, owing to the abolition of slavery and the gradual exhaustion of the rich creek beds. Since 1880 the annual production has averaged about 125 kilograms. This figure was obtained by inquiring of every merchant in the district the amount of metal bought and shipped by him. It was verified as far as

possible by asking the same particulars of the exporting merchants on the coast. It is believed to be under rather than over the true amount.

From the various data obtainable I have estimated the platinum produced in Colombia from 1737 to 1892 at from 16,000 to 20,000 kilograms.

In Borneo very little platinum is now found. One of the most important of the European refiners writes: "The production of Borneo and Brazil is too small to be entered among the statistics of production of platinum. The parcels from Borneo which have arrived occasionally—none recently—only amount to one or two kilos at a time, and the production of Brazil is practically *nil*."

It is only within recent years that any record of the platinum production of Canada has been made. It is probable that a considerable amount of that produced in British Columbia before 1887 entered the United States by way of Washington and Oregon, and was credited to the production of the Pacific coast States. The production since 1887, according to the Canadian Geological Survey, is shown by the following table, which also gives the imports of platinum into Canada since 1883, as shown by the custom-house returns.

Year.	Production.		Imports.*		Year.	Production.		Imports.*	
	Kilos.	Value.	Kilos.	Value.		Kilos.	Value.	Kilos.	Value.
1883......	....	... .	.47	$113	1888......	46.7	$6,000	51.52	$13,475
1884......	....	....	2.31	576	1889......	34.2	3,500	11.07	3,167
1885......	....	....	3.07	792	1890......	31.1	4,500	10.53	5,215
1886	....	....	4.48	1,154	1891.....	65.4	10,000	....	....
1887.....	43.6	$5,600	5.52	1,422					

* The values only are given in the official reports. The weights are calculated on the same basis as those for the United States, under the head "Vases, Retorts, etc." As Canada imports only manufactured platinum, such as crucibles, stills, etc., it is believed that the weights obtained are within a few per cent of being correct.

The amount of platinum produced in the United States is very small, its production being incidental to that of gold in California and Oregon.

PRODUCTION OF PLATINUM IN THE UNITED STATES.

Year.	Kilos.	Value.	Year.	Kilos.	Value.	Year.	Kilos.	Value.	Year.	Kilos.	Value.
1882...	6.2	$600	1885...	7.75	$187	1888...	15.57	$2,000	1891...	14.00	......
1883...	6.2	600	1886...	1.55	100	1889...	15.57	2,000	1892...	11.00	......
1884..	4.65	450	1887...	14.00	1,848	1890...	18.60	2,500			

Imports.—The values of the annual imports and exports of platinum, and the weight of unmanufactured metal imported into the United States since 1882, as given in the following table, are official, having been furnished by the United States Treasury Department. The remaining weights given were calculated by the aid of the column containing the "average price per kilo." For this column I am indebted to the kindness of Mr. H. M. Raynor, the pioneer of New York in the platinum trade, who courteously gave me the invoice prices of his imports of plate and sponge from 1867 to 1890. To these prices three per cent was added for freight, insurance, interest, and customs charges.

In obtaining the weight of unmanufactured platinum imported, the annual value of such imports was divided by the annual price given in the table. In order to obtain the weight of "vases, retorts, etc." imported, the annual value was divided by the above-mentioned price plus $0.75 per Troy ounce ($24 per kilo). This was done in accordance with invoice prices of purchases from Johnson, Matthey & Co. and other manufacturers during those years, whose charges for such metal average three shillings per ounce higher than for plate metal. In cal-

UNITED STATES IMPORTS AND EXPORTS OF PLATINUM.

Year, Fiscal.	Imports.*							Exports.			
	Average Price of Plate per Kilo at New York.	Dutiable. 40% *ad val.* Manufactured.		Free. Ore, Sponge, Plate.		Free. Vases, Retorts, etc.		Manufactured.		Scrap.	
		Kilos.	Value.	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.
1867....	$164.68	2.32	$456	....	....	....	....	....	....	....	....
1868....	154.30	1.55	290	616.95	$95,208	113.59	$20,274	....	....	....	....
1869....	148.21	1.00	184	539.87	80,014	127.68	22,004	....	....	....	....
1870....	143.75	3.67	648	692.93	99,984	96.70	16,294	....	....	....	....
1871 ...	140.50	.26	48	770.42	108,244	136.36	22,470	....	....	....	....
1872....	140.50	1.70	310	651.07	91,472	132.50	21,816	....	....	....	....
1873....	180.04	.17	43	504.16	90,771	.05	9	....	....	....	....
1874 ..	180.04	.65	143	684.32	123,293	292.40	59,698	....	....	....	....
1875....	188.08	.78	173	750.67	141,188	85.19	18,082	....	....	....	....
1876....	192.25	.03	6	735.67	141,207	34.34	7,421	....	....	....	....
1877....	196.43	.04	11	417.03	81,925	84.35	18,611	....	....	....	....
1878....	196.43	1.03	241	611.47	120,121	227.31	50,133	....	....	....	....
1879 ...	220.55	.27	73	753.47	166,178	139.81	34,209	....	....	....	....
1880....	217.33	3.82	964	1,000.59	217,144	173 43	41,827	....	....	3.45	$600
1881....	198.69	1.19	290	1,375.74	273,343	95.55	21,292	....	....	26.55	4,222
1882....	184.54	7.96	1,731	1,417.41	285,731	232.16	48,452	88.68	$19,244	....	....
1883...	212.83	.015	4	1,407.71	298,799	392 34	92,967	88.16	21,600	36.76	6,250
1884....	224.73	....	....	1,290.63	289,898	333.96	83,112	72.32	18,587	6.27	1,130
1885....	233.08	.015	3	1,184.66	285,239	65.44	17,473	....	....	37.43	7.000
1886....	233.08	.09	25	1,453.12	356.020	338.07	83,752	15.25	4,048	10.69	2,000
1887....	233.08	.21	61	1,751.16	438,516	229.08	58,925	8.30	2,200	93.59	17,500
1888....	236.94	.056	15	2,424.29	565,459	199.97	52,295	....	....	....	....
1889....	261.38	1.00	299	2.342.08	548,350	157.17	44,879	....	....	31.10	6,500
1890....	469.39	.75	39	2.563.02	702,093	322.30	159,057	....	....	116.90	45,835
1891....	369.72	.012	49	2,204.35	972,989	66.59	26,228	....	....	43.59	12,900
1892....	315.07	....	....	1,774.96	505,852	170.63	53,763	1.15	400	30.75	7,750
Totals	....	28.568	$6,106	29.917.75	$7,089.038	4,246.97	$1,075,043	273.86	$66,079	437.08	$111,687

culating the weight of manufactured platinum, its average price was taken at the price of plate metal plus $1 per ounce, or $32 per kilo. The weight of scrap was calculated on a price 20% lower than plate metal during the same year. Although these weights are not exact, it is believed that they are within five per cent of the actual amounts imported.

IRIDIUM.

This metal was first isolated by Tennant in 1803 during an examination of "platinum residues." Its principal occurrences are in Russia and California in iridosmine and platiniridium, but it is also found in almost all native platinum. It has not yet been discovered *in situ,* but Mr. John Holland of Cincinnati informs me that he has lately received samples and offers of a large quantity of the metal from parties in Idaho who claim to have a lode of the ore. Some years ago a correspondent of the *Engineering and Mining Journal* wrote that a mint assayer had reported 2½% of iridium in a copper ore from Arizona, but nothing more has been heard of this occurrence.

Properties.—Iridium is a lustrous, steel white, extremely hard metal—almost as hard, indeed, as the ruby. It has a melting point of 1950° C. according to Violle, and a specific gravity of 22.38—next to that of osmium, the highest known. It is insoluble in all single acids, and in mass is not attacked even by aqua regia; in powder, however, it is soluble in small quantities after being heated for some time. It is unalterable in the air at an ordinary temperature, and although it may be oxidized at a red heat, it gives off this oxygen upon raising the temperature above

* Before 1867 the Treasury Department kept no record of the importations of platinum.

1000° C. These valuable qualities have failed to provide a very extended use for the metal, because until very recently the difficulty of working it on account of its infusibility and hardness made its cost prohibitory. That this is no longer the case is owing to Mr. John Holland of the John Holland Gold Pen Company, and to Prof. William L. Dudley of Vanderbilt University. A number of the earlier chemists, among them being Vauquelin and Children, reported having melted the metal, but it is now known that they were working on an iridium-platinum alloy; and even Dr. Hare, the discoverer of the oxyhydrogen blowpipe, who reported having fused it in quantity, probably worked on an impure iridium. The first to prepare the pure metal on any large scale were St. Claire Deville and Henri Debray,* whose method is probably the best yet known; but as made by them it consists of sponge, which is fusible only in small quantities by the aid of an electric furnace. Perhaps the most prominent investigators of iridium and its kindred metals are Messrs. Johnson, Matthey & Co. of London, who were the first to prepare a pure alloy of platinum and iridium, which was adopted in 1872 by the International Bureau of Weights and Measures, for the construction of standard weights and measures.†

Metallurgy.—Pure iridium can be prepared in the following way: Iridosmine is fused with five times its weight of zinc, which metal is finally volatilized by heating the alloy in a carbon crucible. The porous friable mass left is then stamped until fine enough to pass through a lawn sieve, the powder is mixed with five times its weight of barium dioxide—great care being taken in weighing the dioxide—and the mixture heated in a crucible at the fusing point of silver for one hour. The black mass obtained is then boiled with aqua regia until all the osmium is volatilized, when a sufficient quantity of sulphuric acid is added to exactly precipitate the barium. The filtrate, acidulated with hydrochloric acid, is evaporated to small bulk, and ammonium chloride is added to saturation; the solution is then evaporated to dryness, and the residue washed and ignited. The spongy iridium obtained is fused with potassium nitrate, and then washed with water until all the potassium ruthenate is dissolved. The residue is finally fused with lead, and the alloy obtained heated with nitric acid and aqua regia, which dissolve the lead and leave chemically pure iridium. Deville and Debray, who worked out this method, succeeded in melting a little over a kilogram of the metal by the use of the oxyhydrogen blowpipe. The metal thus obtained is in the form of sponge or "black," a condition in which its use is limited, on account of its practical infusibility.

The device of pointing gold pens with iridosmine has created quite a demand for grains of a certain size, but not more than 10 per cent of those found are suitable, and they command a very high price. In 1880 iridosmine was worth about $4 per ounce, or $130 per kilo, in Russia, but in the United States selected grains sold for $3000 to $4000 per kilogram. During that year one kilogram, containing on an average about 160 grains to the gram, was consumed in this country. About this time a new demand was created by the invention of the Mackinnon pen, which requires an iridium point drilled through the centre—a use for which only the larger pieces are suitable.

Mr. Holland, in experimenting for a substitute, found that in heating iridosmine

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**Ann. Chim. Phys.* [3] 56, p. 385; *Compt. Rend.* 78, p. 1502.

† *Proc. Roy. Soc.* 1879.

and phosphorus together part of the osmium is volatilized as osmic acid and is replaced by phosphorus, forming iridium phosphide, which is liquid at a white heat, insoluble in acids, and when cold even harder than the native alloy, being 9 on the scale. For Mackinnon-pen points the fused phosphide is poured between two slabs of iron, which are suddenly closed as the metal cools, making a very compact sheet. This sheet is then broken, the pieces ground flat, drilled, soldered to the end of the pen, and ground to shape. For this use, and for pointing tools, it is not necessary to remove the phosphorus. According to an analysis made by Prof. F. W. Clarke, the phospho-iridium contains from 7.52% to 7.74% of phosphorus and a trace of osmium, the iridosmine from which it was made containing 15.80% of osmium.

For use at high temperatures it is necessary to de-phosphorize the alloy. This, Prof. Dudley has found, can be done by heating the phosphide in a bed of lime, by which a pure iridium is obtained, as infusible as the native metal.

Uses.—The alloy of pure iridium and pure platinum has been adopted for the standards of weights and measures on account of its indestructibility, extreme rigidity, capacity for a high polish which will not tarnish, high co-efficient of electricity, and for its great specific gravity. Mr. Matthey recommends for standard measures of length an alloy of 85% platinum and 15% iridium, in tubular form; for standard weights, an alloy of 80% platinum and 20% iridium, in cylindrical form. He has also proposed an alloy of 90% platinum and 10% iridium for gun vents, but phospho-iridium appears to have displaced it.

Iridium in the condition of sponge and oxide is used in photography and the ceramic art for obtaining a dense black, and by jewelers for obtaining black under a white or transparent enamel. Its use in all these cases is due to its infusibility.

According to Roessler & Hasslacher of New York, not more than 500 grains per annum of iridium oxide are used in the ceramic art in the United States. For other uses see "Uses of Platinum."

The first to apply iridosmine to the manufacture of gold pens was Mr. J. I. Hawkins of England, who made the first iridium-pointed pen in 1833. It is still used by some manufacturers of gold pens, Mr. John Foley of New York informing me that he uses about 300 grams of selected points per annum. A like amount is probably used by A. W. Faber & Co. According to Mr. Foley, the best "iridium" comes from Russia and is worth from $10 to $40 per oz., according to quality. The crude material is separated into the different sizes required, by sifting through brass sieves; finally the best grains are picked out by hand with the aid of a microscope. These are worth from $100 to $200 per oz. The very small, flat, thin, and irregularly-shaped grains are valueless. In making the pens a point of the proper size is either soldered on or the gold is melted around the point, or "sweated in," as it is technically called. The point is then ground square, after which the pen is rolled out, hammered to give it the required elasticity, the edges cut, the pen stamped, and the edges raised to shape. The pen having been given its shape, the point is cut by the aid of a copper disk charged with emery and oil, and the gold part is then slit by a fine steel saw. Finally the point is ground to shape and burnished.

Since its discovery phospho-iridium has had a rapidly increasing use. For the manufacture of "diamond" points for gold pens, Mr. Holland now uses about

3 kilograms per annum, an increase of 20% per annum since 1880. There was also used in 1891 about 1.6 kilograms in pointing fine mechanical tools. It is also claimed that it is superior to steel for draw-plates for gold, silver, copper, and very fine iron wire, since it has no temper to lose, and that it is tougher than the ruby and not so likely to break.

Mr. Henry Troemner of Philadelphia has introduced its use for knife-edges in fine balances of great accuracy. One of these balances, made for the New York Assay Office, is sensitive to 0.01 gram with a load of 30,000 grams in each pan. In this balance not only the knives, which are 4½ inches long, but the bearings also, are made of phospho-iridium. The alloy also has a limited use in the manufacture of electrical contact points.

Iridium Plating.—Although a process for plating with iridium was announced some years ago, it was not until 1891 that it became a commercial success. The process originated with Prof. William L. Dudley of Vanderbilt University, then General Manager of the American Iridium Company, the present owner of the patent. The first experiments were made with a bath of the double sodium-iridium chloride, using an anode of phospho-iridium. This gave a fine reguline deposit, but it was thin and liable to scale. Later on the composition of the anode was changed, which resulted in obtaining a more constant bath and a thicker deposit, and Prof. Dudley took out patents for his method in 1887. Later still Mr. John Holland became manager of the company, and by various improvements placed the process on a commercial basis. At present the company is plating articles at the cost of silver-plating. The process, as described by Mr. Holland, is as follows: "The bath consists of a slightly acidulated solution of the double sodium-iridium chloride. The article to be plated, which may be brass, copper, german-silver, or iron, is after a thorough cleansing suspended in the bath, and a strong current passed for 20 minutes." The deposit obtained is compact, hard, and of a silvery-white color that will not tarnish. It is claimed that iridium plate is particularly adapted for reflectors, spoons to be used for medicine, works of art, etc. Although this industry only began in 1891, there was, according to Mr. Holland, 50 oz. of iridium used in plating in that year.

Production.—Exact figures concerning the production of iridium are not obtainable, nor have they ever been published in the Government reports of any country. In Russia, in consequence of the frequent adulteration of gold-dust with iridium, it is forbidden by law to possess platin-iridium or iridosmine or to sell them to any one except the Imperial Mint. As iridosmine will not alloy with gold, the rolls and dies of the mint were often indented and injured during the coinage of gold adulterated with it. The iridosmine collected by the Russian Mint is not for sale, and no exact estimate of its quantity has been published. Nevertheless the following figures show approximately the world's production. Assuming that the native platinum of Russia contains 2% of iridium alloyed with it and 1% of iridosmine,—this is the average of a large number of analyses,—the production of iridium in 1891 amounted to 84.4 kilograms and 42.2 kilograms of iridosmine. From this it is estimated that the Russian Government must have a stock of about 2000 kilos. For Colombia the percentage of iridium in the platinum is less, being about 1%, and iridosmine ½%, which would give 1.2 kilos of iridium and 0.6 kilo of iridosmine. In Canadian platinum the percentage of iridium is

about 1%, and of iridosmine about 5%, which on an output of 31 kilos of platinum would give 0.3 kilo of iridium and 1.5 kilos of iridosmine. The platinum of the United States contains a slightly higher percentage of iridium than that of Canada, being about ¾%, while the iridosmine amounts to at least 15%, which on a platinum production of 15.5 kilos would give 0.128 kilo of iridium and 2.32 kilos of iridosmine. The total production of the world therefore is about 170.25 kilos of iridium and 47.65 kilos of iridosmine. This amount includes a small quantity of iridosmine occurring in the gold of California. The annual production of this has been furnished to me by the Director of the Mint and will be found in the table below. The iridium alloyed with the platinum is not separated completely from it, a small percentage being left to give strength, hardness, and rigidity.

The following official table of imports into the United States has been supplied by the Treasury Department:

IMPORTS OF IRIDIUM INTO THE UNITED STATES.

Year.*	Value.	Year.*	Value.	Year.*	Value.	Year.*	Value.
1873	$429	1878	....	1883	$495	1888	$2
1874	275	1879	$425	1884	....	1889	
1875	500	1880	....	1885	5852	1890	
1876	180	1881	1730	1886	....	1891	
1877	311	1882	7307	1887	3	1892	

* Fiscal years ending June 30 prior to 1886 ; calendar years subsequently.

IRIDOSMINE RECOVERED FROM GOLD-DUST AT THE SAN FRANCISCO MINT.†

Year.	Kilos.	Year.	Kilos.	Year.	Kilos.
1882	0.832	1886	0.800	1890	0.809
1883	1.026	1887	0.731	1891	0.785
1884	0.743	1888	0.715	1892	...
1885	0.824	1889	0.754		

† Reported by Director of the United States Mint.

OSMIUM.

This metal, at once the heaviest and most refractory known, was first isolated by Tennant in 1803. Its name is indicative of the pungent odor of its oxide, OsO_4. It occurs alloyed with iridium in iridosmine, and is also a frequent constituent of native platinum.

Metallurgy.—The method of Deville and Debray is probably the best for the preparation of pure osmium. Finely pulverized iridosmine is mixed with 5½ times its weight of barium dioxide. If iridium is also to be obtained, the exact amount of barium dioxide added must be known in order to determine later on the amount of sulphuric acid to be added to precipitate it. The mixture, after being ground in a porcelain mortar, is heated for several hours at the fusing point of silver, the crucible being well covered to prevent the escape of osmic acid. Upon cooling, the black homogeneous mass is coarsely broken and, moistened with water, introduced into a glass retort, where eight parts of hydrochloric acid and one part of nitric acid are added. The osmium is then distilled as osmic acid. The receiver should be cooled with care to prevent the escape of the osmic vapor, which is highly poisonous. To obtain the metal with certain purity, the first distillate should be redistilled and the osmic acid collected in a receiver containing

dilute ammonia. This solution of ammonium osmiate is saturated with hydrogen sulphide, and then boiled and filtered. The sulphide obtained should be dried at a low temperature, then decomposed by heating for four or five hours at the melting point of nickel in a tightly closed carbon crucible, when osmium in grains is obtained. The grains have a bright metallic lustre and a slightly blue color. Upon reheating in a closed crucible, the osmium becomes denser, until its specific gravity reaches 22.477. This metal is without odor and can be heated to the melting point of zinc without oxidation. Crystals of osmium can be obtained by melting the grains with eight parts of tin and heating the alloy to a bright red heat for some time. At the moment of cooling, the osmium separates in a finely crystalline state, and can be separated from the tin by dissolving the latter in acid. If a like alloy is made with zinc, the osmium separates on cooling as an amorphous powder which is highly combustible. However, if the zinc be driven off by heat, the osmium is obtained in metallic grains, which are not compact, but are harder than glass. All attempts to fuse osmium have failed. When heated in a closed vessel to the fusing point of ruthenium, the osmium commences to volatilize, but settles immediately beyond. At still higher temperatures it volatilizes completely. Osmium in the form of powder can easily be prepared in the following manner: Osmium tetroxide obtained by oxidizing iridosmine is passed into a receiver containing caustic potash. To this solution an excess of hydrochloric acid is added, and the whole is then digested with mercury in a tightly closed bottle at 40° C. This operation should be performed with great care. The osmium is reduced by the mercury, and unites with it to form an amalgam which, when distilled in a current of hydrogen, leaves the metallic osmium in the form of powder. In this state it is black, without lustre, and has a specific gravity of 10.

Uses.—As iridosmine it is used for pointing pens and tools. The only other use is in microscopy, the tetroxide or osmic acid being used to stain and preserve anatomical specimens.

PALLADIUM.

This metal, the most fusible of the platinum group, was discovered by Wollaston in 1803. It occurs both native and alloyed with gold in Brazil. It is found associated with gold at Tilkerode, in the Harz, and is a frequent constituent of native platinum. It is reported that palladium occurs at the Esmeralda Mine in Lemhi Co., Idaho, in considerable quantity. The mine is one of free milling gold, and the palladium, of which there is from one to two and one half ounces per ton, is amalgamated with the gold.*

Metallurgy.—Palladium is obtained from platinum residues by neutralizing the solution with sodium carbonate and adding mercuric cyanide. The palladium is precipitated as palladium cyanide, which upon ignition yields spongy palladium, and this in turn can be melted in the furnace described under "Platinum." To purify it, it is dissolved in aqua regia, and re-precipitated as above. The fused metal spits on cooling, its color resembles that of platinum, and it has a specific gravity of 11.4 at 22.5° C. At the melting point of iridium it begins to boil, and undergoes partial oxidation. It is soluble in hydrochloric acid. The sponge

* *Wood River Times*, Hailey, Idaho.

has the power of occluding gases and promoting chemical combinations. It forms an alloy with hydrogen, which has a bright metallic lustre, is tough, conducts electricity, and is slightly magnetic. Its specific gravity is 11.06.

Uses.—That palladium has not come into more general use is owing to its cost. It has a brilliant white silver color, and, owing to its unalterability in the air and in the presence of sulphuretted hydrogen, could advantageously replace silver in many ways. Unfortunately it is so rare as to be worth nearly as much as gold. The first use of the metal was suggested by Wollaston, who advised that the graduated part of the large mural circle constructed by Troughton for the Royal Greenwich Observatory be made of an alloy of one part palladium and six parts gold. Since then small quantities have been used for the graduated parts of circles and for some mathematical and surgical instruments. It is used to some extent instead of gold for filling teeth, probably 0.6 kilogram being so used annually. Its latest application in the fine arts is for the inner band of compensation balance-wheels and hair-springs for fine watches. The alloy first used for this purpose was described in *Dingler's Polytechnische Journal* as containing from 60% to 75% palladium, 15% to 25% copper, and 1% to 5% iron. Pailliard's more recent patents call for an alloy of from 75% to 80% palladium and from 25% to 26% gold, silver, and copper. This alloy is non-magnetizable, and owing to the development of the use of electricity has come rapidly into use. The Geneva Watch Company, which controls the patents for the United States, buys the palladium alloy from Johnson, Matthey & Co., London, who prepare it in shape and size ready for rolling and stamping. This company has courteously furnished me with the following details concerning its importations of balance-wheels and springs (which are made in Geneva) since 1886:

IMPORTS OF PALLADIUM INTO THE UNITED STATES.

Year.	Balance-Wheels.		Springs.	
	Wt., Grams.	Value.*	Wt., Grams.	Value.
1886	74.12	$666	8.75	$28
1887	554.27	4,980	136.69	437
1888	4626.85	41,571	1561.88	4,993
1889	9939.32	88,804	2253.64	7,204
1890	1133.59	10.185	47.54	152

* These values are for the wheels complete, with gold compensating-screws; the weights are for the palladium-alloy wheel alone, without screws.

RUTHENIUM AND RHODIUM.

The occurrences of these metals will be found under "Platinum." Neither metal is used in the arts, and as the methods of preparing them have but a laboratory interest, those desirous of information are referred to the memoirs of St. Claire Deville and Debray.

NOTE.—The imports of platinum into the United States from July 1st, 1892, to January 1st, 1893, have been as follows:

	Manufactured. Value.	Unmanufactured.		Retorts, Vases, etc.
		Kilos.	Value.	
July	....	51.8	$13,116	$5,190
August	....	131.8	30,730	402
September	..	172.7	37,147	7,273
October	$142	175.3	33,307	1,424
November	....	158.1	29,724	1,118
December	6	99.1	23,164	128
Total	$148	788.8	$167,188	$15,535

Platinum Market.—Since 1867, at which time platinum was worth $4.40 to $4.90 per oz., the price has almost continually advanced. For some years previous to 1889 the price in London, for large quantities, ranged from $6.75 to $8 per oz.

In the fall of 1889, on account of a "corner" and the increasing demand for electrical purposes, the price of the metal ran up to about $17.50 per oz. at the highest point. In 1891 the price commenced to fall, and during October, 1892, it fell to $7.50, owing to the increased output induced by the high prices. Old metal amounting probably to more than 100,000 oz. was sold to the refiners at high prices. Platinum filaments in electric lamps were lessened, and parties in Russia and elsewhere, who imagined that the advance would continue, bought and held considerable quantities on speculation. When the tide turned they realized at a great loss.

During January, 1892, the price was about $11 per oz., the tendency being downward: in July it reached $8.50; in November, $6.50 or $7. About the middle of November a sudden rise set in, and in December platinum was worth $10.50 to $11 per oz., with the market unsettled.

PLUMBAGO.

PLUMBAGO, or graphite, is a mineral of metallic luster, its color ranging from iron-black to dark steel-gray. Its hardness is 1.2 and its specific gravity from 2.25 to 2.27. It soils paper and has a greasy feeling by which it is easily recognized, being distinguished from molybdenite by the streak, that of molybdenite having a slightly greenish cast. Molybdenite also affords a test for sulphur before the blowpipe.

Occurrence.—Graphite occurs in several places in the United States and has been mined in Wyoming, Pennsylvania, New Jersey, and at Ticonderoga, N. Y. The last-mentioned locality is the only one where the mineral is found of sufficiently fine quality to be used in the manufacture of lead-pencils. A crude graphite, adapted for the manufacture of crucibles, stove-blacking, etc., is found in Rhode Island in conjunction with anthracite coal. Most of the mineral used

in the United States is imported from Ceylon, the domestic production being far below the demand.

Production.—The mines at Ticonderoga, N. Y., are owned and operated by the American Graphite Company, which is a branch of the Joseph Dixon Crucible Company, of Jersey City, N. J. The production of graphite in the United States, together with the imports into the country, is shown in the following table :

PRODUCTION AND IMPORTS OF REFINED GRAPHITE.

Years.	Production.		Imports (*a*).			
			Unmanufactured.		Manufactured.	Total Value.
	Pounds.	Value.	Pounds.	Value.	Value.	
1867	....	....	27,113	$54,131	....	$54,131
1868	....	....	68,620	149,083	....	149,083
1869	....	....	74,846	351,004	....	351,004
1870	....	....	80,795	266,291	$833	270,124
1871	....	....	51,628	136,200	3,754	139,954
1872	....	....	96,381	329,030	....	329,030
1873	....	....	157,539	548,613	....	548,613
1874	....	....	111,992	382,591	....	382,591
1875	....	....	46,492	122,050	....	122,050
1876	....	....	50,589	150,709	17,605	168,314
1877	....	....	75,361	204,630	18,091	222,721
1878	....	....	60,244	154,757	16,909	171,666
1879	....	....	65,662	164,013	24,637	188,650
1880	1,880,000(*b*)	$49,800	109,908	278,022	22,941	300,963
1881	400,000	30,000	150,927	381,966	31,674	413,640
1882	425,000	34,000	150,421	363,835	25,536	389,370
1883	575,000	46,000	154,893	361,949	21,721	383,671
1884	....	....	144,086	286,393	1,863	288,256
1885	327,883	26,231	110,462	207,228	....	207,228
1886	415,525	33,242	83,368	164,111	....	164,111
1887	416,000	34,000	168,841	331,621	....	331,621
1888	400,000	33,000	184,013	353,990	....	353,990
1889	(*c*)	72,662	177,381	378,057	....	378,057
1890	(*d*)	77 500	255,955	594,746	....	594,746
1891	1,506,065	75.350	234,900	554,857	....	554,857
1892	1,298,363	64,920	149,408	379,069(*e*)	....	379,069

(*a*) For fiscal years until 1888; calendar years subsequently. (*b*) Crude graphite. (*c*) Value of 7003 tons crude graphite. (*d*) 1500 tons of crude graphite and 600,000 lbs. of refined. (*e*) Six months.

Uses.—Graphite is largely used for pencils and as a lubricant, for both of which purposes it must be soft and of high grade. Lower grades are used for crucibles, stove-blacking, foundry facings, and as a substitute for red lead in pipe-fitting. It is also extensively employed as a paint for covering smoke-stacks, boilers, tin roofs, etc., for which it has proved very durable.

Price.—The price of graphite, or plumbago, as it is commonly called, varies according to its quality. It is divided into four grades, viz., large lump, ordinary lump, chip, and dust. Large and ordinary lump are worth from $4 to $5 per 100 lbs., chip from $3.50 to $4, and dust from $2.75 to $3.50. The quality of plumbago depends as much upon its physical structure as upon its chemical composition.

PRECIOUS STONES.

By George Frederick Kunz.

The most noteworthy events in mining for gems and precious stones during the past year have been the continued success in the operation of the turquoise mines of New Mexico, the opening of promising opal mines in Washington, and the commencement of work in the fancy sapphire bars of Montana. As yet, however, the turquoise mines are the only producers of gems in the United States whose output has attained proportions of any importance. The total yield of turquoise during 1892 is valued at $125,000; of the other stones, the production of pearls in Wisconsin, Tennessee, and Texas may be put at $50,000; sapphires in Montana, $5000; opals in Washington, $5000; and garnets in New Mexico, $3000—a total of $188,000.

Sapphire.—Sapphires are found in Montana at Eldorado Bar, Spokane Bar, French Bar, Ruby Bar, and for some six miles along the Missouri River. Spokane Bar at Stubb's Ferry, twelve miles east of Helena, is about the central point. No systematic attempts were made to work these bars for gems until 1891, although they had previously been pretty thoroughly sluiced for gold. The sapphires, of which specimens were occasionally sent to the large cities, did not, until recently, receive much recognition, owing to the high price of cutting gems of this class and the small demand for stones other than of positive color, such as true ruby-red or sapphire-blue.

In 1889, an area of about 4000 acres was purchased by a company, which had the property examined by mining engineers, who estimated that Eldorado Bar would yield some 2000 ounces of sapphires to the acre, only part of which, however, may be of such quality as will warrant cutting into gems. The stones found embrace a great variety of the lighter shades of red, yellow, blue, and green, the latter being rather a blue-green than an emerald-green. Nearly all the stones, when cut, have a metallic luster, which is strikingly peculiar to those from this locality. No true red rubies nor any true blue sapphires have been found.

Several minor companies have been formed, or are contemplated, to operate in this district, one known as the Spokane Sapphire Company owning that part of the river near Stubb's Ferry, including Spokane Bar. During 1892 operations have been actively pushed on the property of the Ruby and Sapphire Mining Company, under the superintendence of the well-known mining engineer Mr. A. B. Wood. During the past year no gems from this property have been placed on

the American market; and up to this time it is impossible to state how the gem market of the world will accept these "fancy colored" stones, seeing that the demand in the past has been only for the standard ruby and sapphire. A number of minor deposits have been found in the property adjoining that of the larger company, and various lots of gems have been sent to New York; but the sale for the year, including those sold generally at a very "fancy" price by the Helena (Montana) jewelers, does not probably exceed $5000.

At all the bars along the Missouri River the sapphires are principally found in a layer of auriferous glacial gravel, a few inches in thickness, lying on a slaty bed-rock. While work was being carried on at the Ruby Bar deposit, a mastodon tusk three feet in length was found in the sapphire layer. Among some of the associated minerals observed by the writer were white topaz in brilliant crystals not over ¼ of an inch in length, similar to those from Thomas Mountain, Utah; garnets in rounded grains, occasionally as large as a pea, and rich ruby-red in color, often mistaken for rubies; cyanite in broken translucent crystals—white with blue patches—½ in. in length and ⅛ in. in diameter; cassiterite (stream tin) in concentric nodules, none over ¼ of an inch in diameter; limonite pseudomorphs after iron pyrites, in a variety of imitative and concentric shapes showing a radiated structure when broken; chalcedony in small irregular and imitative pieces often an inch in length; and white calcite in small masses.

As to the original source of the sapphire found at the bars of the Missouri River, it may be said that during the winter of 1889 and 1890 a dike of eruptive rock was found cutting the slaty rock at Ruby Bar, on which rests the glacial gold-gravel. In this eruptive rock there were found crystals of sapphire, pyrope garnet, and sanidine feldspar; and there can be no doubt that all the sapphire along the bars of the Missouri River is the result of the disintegration of a rock similar to this. It is evident that some outcroppings have been eroded by glacial action north of all the bars, but it is doubtful from what precise locality. It could not have come from the outcrop at Ruby Bar, because this locality is six miles south of Eldorado Bar where a quantity of sapphires have been found, but rather from some hidden dikes north of Eldorado Bar. Mining in this district may bring to light other dikes, as did the drifting of a level at Ruby Bar some hundreds of feet from the outcrop of the original four-foot dike. H. Miers states that the rock is a vesicular mica-augite-andesite, containing an abundance of brown mica and porphyritic crystals of augite. The ground-mass consists chiefly of feldspar microlites, with a considerable amount of glassy interstitial matter and much magnetite. Many of the cavities are occupied by a brown glass, which appears yellow in thin sections, and displays a spherulitic structure originating in the sides of the cavities. It is, of course, difficult to say whether or not the sapphires can have been caught up by the augite-andesite from schists or other rocks cut through in coming up, as may have been the case in the occurrences in the Eifel Laacher See, at Unkel, and in Auvergne (Espailly), France.

Turquoise.—During the past two years turquoise has been actively mined by two companies—the American Turquoise Company and the Azure Turquoise Company. The former is operating six miles from Los Cerrillos, New Mexico, opening some of the mines originally worked by the Indians, and has found turquoise in many respects, including color, equal to the finest Persian material.

Its stability in retaining color is fully as great, not changing within a short time, like the Egyptian turquoise, which was so extensively placed on the market about the time that the Persian mines were ceasing to yield. Stones have been found at these new localities weighing as much as 60 carats, one of which is valued at $4000; and it is now possible for the first time in the past half-century to match a necklace of perfect turquoise.

The Azure turquoise mines, situated in Grant County, New Mexico, produce material of rather a robin's-egg blue, that is, with a faint greenish tinge which is either due to a partial change or metamorphism which has taken place while the turquoise was in the rock, or may be a local peculiarity. The stones are not the sky-blue of the more northern locality, but it is claimed by the owners of the mine that they are not subject to a change of color. Turquoise has always been known as an unstable gem. Even the finest Persian stones are likely to change occasionally with scarcely any warning, the alteration probably being due to the turquoise coming in contact with acid exhalations from the skin, or fatty acids or alkalies in the soap used to wash the hands.

The sale of turquoise during the year 1891 from these two localities probably amounted to $125,000. A number of futile attempts to mine turquoise have been made by other parties, but the only definite results have been attained by the two concerns named above.

Opal.—In August, 1890, Mr. James Allen, a jeweller of Yonkers, N. Y., detected what proved to be fire-opal among a pile of rock from a depth of 22 ft. broken in digging a well on the farm of William Leasure, near Whelan, 20 miles southwest of Colfax, in the State of Washington, and the gem was found to occur more or less plentifully in cavities in the rock exposed at the bottom of the well.

This opal occurs in a much altered basalt, in pieces varying from the size of a half-pea to that of a hen's egg; the smaller nodules are very rich in color, but the larger ones often have little or no play of tints. The quality of some of the specimens is very fine, and if the material is as abundant as is supposed, and is properly worked, it is likely to be one of the most promising of our precious stones from a financial point of view. Mine buildings have been erected, and the locality has been named Gem City.

These mines were worked for a few months in the fall of 1891, and for three or four months during the past summer, the yield amounting probably to several thousand dollars' worth of fine opals, in many respects equal to the best material from the Hungarian or Australian mines. One gem from this district, weighing 3½ carats, was held at the extravagant figure of $500—entirely, however, on account of its American origin, as a Hungarian gem of equal value would not have sold for one half the price.

Garnets.—Garnets have been sent, as in former years, from the Navajo Reservation in New Mexico by the Indian traders, yielding gems possibly to the value of several thousand dollars during 1892. Associated with them are peridots, but as the color of these is not up to the standard desired, there has been but a limited demand for them.

Tourmaline.—A new locality for pink tourmaline is given by Mr. Orcutt in a report on the minerals of the Colorado desert. It is found in the mountains of Lower California, south of the Alamo mines,—though whether within the actual

limits of the desert or not, he does not specify,—in an identical association with that from Rumford, Maine, i.e., rose-colored tourmaline in lepidolite. Recently a large deposit has been found in San Diego Co., Cal., which has afforded many fine souvenirs for cabinets.

Asteriated Quartz.—This stone has been sold during the past year by lapidaries at Ottawa, Ont. It was cut from transparent massive colorless quartz which had been found between plates of muscovite, and when cut in the proper direction and viewed in a strong light, showed remarkable asteriations.

Quartz.—An interesting discovery has been made at Placerville, Eldorado County, Cal., by Mr. James Blackiston, in a quartz ledge running north and south, and dipping eastward 45°–50°. The rock of the ledge, partly decomposed and partly unaltered, is traversed for perhaps 100 ft. by a vein of crystallized quartz varying from 6 to 14 in. in width. This vein is also decomposed, and is filled with a reddish earth or sand, which can be dug into with a stick or board. It is full of quartz crystals of all sizes, from that of a man's finger up to stones weighing 80 or 90 lbs. Some have peculiar interest from remarkable inclusions of chlorite, 3 mm. to 5 mm. in thickness, at several depths in the crystal—thus marking successive stages of crystal-growth, and making very striking phantoms, generally of green chlorite on white quartz layers. Of still greater interest, however, are other quartz crystals, two to four inches in length and one to two inches in diameter, containing at and near their centers inclusions resembling groups or clusters of dolomite or siderite crystals, cream-white to brown in color, and consisting of many curved rhombohedra from 2 mm. to 4 mm. in diameter.

Titanite (*Sphene*).—A very remarkable discovery of titanite has been made by E. Schernikow at the celebrated Tilly Foster iron mine, Brewster's, Putnam County, N. Y., where several hundred magnificent crystals have been obtained. In size they vary from one to two inches in length; nearly all have highly polished faces, and some are beautifully twinned. They are of fine yellow shades, many of them transparent, and a number are large enough to cut into gems of from one to fifteen carats each. These were found during the summer of 1891, and are among the finest specimens of this mineral that have been observed recently in any locality, equaling some of the best crystals from Tavetsch, or other celebrated places abroad. Over $1000 worth were sold as gems.

Agatized Wood.—In the eighth annual report of the United States Geological Survey for 1886–87, Prof. Lester F. Ward has contributed the most exhaustive treatise on the geological distribution of fossil plants throughout the world—including silicified and agatized wood—that has appeared up to the present time. He says: "These remarkable petrifactions are believed to occur in the Shinarump group of Powell, and their mode of occurrence is described by him in his geology of the Uintah Mountains, 1876, p. 69. These great trees of stone are believed by the Indians to be the shafts of their thunder-god, Shinauav, and from this Major Powell named the group, which he regards as of Cretaceous age."

The writer found that Chalcedony Park, which is the nearest of the three so-called forests in this formation to the Atlantic & Pacific Railroad, is about a mile square, and is enclosed by table-lands from 50 to 100 feet in height. Nearly all the agatized wood is on the flat plain below these table-lands, and rests on layers of sandstone. The lower layer is chocolate-red, another white, another black,

and another a compact gray sandstone, and on these rests a layer of white sandstone, in which originally was found all the wood at this locality. It is by the washing and weathering away of this formation that the tree-trunks have rolled down to the level plain below, as none of those lying below were ever in place there. None that are in the upper layer occur in the upright position, nor were any roots visible; and since none of the trees retain any of the original bark, it seems very probable that this whole deposit was once the bed of an inland sea or lake.

There exist two other deposits of jasperized wood, respectively eight and sixteen miles distant from Chalcedony Park; and a number of outcrops of this material occur along the line of the Atlantic & Pacific Railroad, although the quality is not so fine as that of the three original deposits. Within three miles of Los Cerrillos, N. M., there is a small fossil forest, with agatized and jasperized wood very closely resembling that of the famous Chalcedony Park in Arizona. Two sections from this locality, weighing about a ton each, are in the Historical Society's collection at Santa Fe, N. M.

Dr. Alexis A. Julien, who has made a careful microscopic study of the jasperized wood, made the following communication to the New York Microscopical Society at the January meeting, 1892:

"In the jasperized wood from Arizona many of the wood-cells are traversed by the well-preserved mycelium of a fungus, secreting iron oxide, of which the still living species has already been described (Jour. of the New York Microscopical Society).

"The fine threads are silicified and heavily coated with yellowish to reddish-brown ferric oxide, and, by their minute and close branching, form spongy masses of cylindrical shape, often somewhat curved or spiral, and of a little less diameter than the wood-cells along which they lie. It was often noticed in a sliced thin section of the silicified wood, that these spongy cylinders of iron oxide adhered mostly to the same side of the wood-cells which enclosed them. In other cases, the walls of several wood-cells appeared to be broken down in the vicinity of the larger ocherous cylinders, as if by erosion through the agency of the organism, producing irregular cavities, now filled with clear quartz.

"Another mode of growth of the fungus was well shown in many branching plants which have insinuated themselves within the thin lamellæ which make up the walls of the wood-cells, and so have crossed over several cells through and inside of their walls, but without entering the cells.

"The mode of introduction of the fungus into the wood is clearly shown in many thin veins of agate which cross the sections and indicate cracks in the trunk of the original tree. In these veins, as well as in the erosion cavities referred to above, many fungus spores were observed, sprouting into mycelium, of which some of the branches were noticed penetrating through the walls of the neighboring wood-cells.

"From these as well as from other facts observed on the plant now living, the following conclusions were drawn:

"1st. That the tree fell and was submerged in a shallow sheet of gently running water, such as that which oozes through the cedar swamps of the Atlantic Coast down to the sea at the present day.

"2d. The wood-tissue of the tree was attacked by the water fungus immediately after its fall, and this growth mainly progressed on the lower side of the cells in the prostrate tree. After the decay and loosening of the bark, the floating spores of the fungus evidently made their entrances into the tree through the cracks in its trunk.

"3d. The slowly moving current under the swamp brought by infiltration into the wood-cells a constant supply of water charged with organic salts of iron, etc. The coloration of the wood has been effected, not by chemical or mechanical agency, but entirely by organic secretion and deposit of ferric oxide, etc., by this interesting species of water-fungus.

"4th. The complete silicification of the wood finally ensued, with a deposit of the chalcedonic and crystalline quartz, producing varieties of jasper, banded chalcedony, ruin-agate, etc.

"In the silicified wood from Barillas Springs, Tex., still more delicate and complex forms of the same fungus were detected in a perfect state of preservation."

Pearls.—During the past few years pearl-fishing in Wisconsin has been extensively carried on along the Pecatonica River and the creeks emptying into it, principally between Darlington and Argyle, Lafayette County, and also on Apple River. Many fine pearls remarkable for brilliancy and luster have been obtained, among them some of the finest copper-colored, russet, purple, and rich pink tints ever found. Some pearls weigh over 50 grains each, and the finest ones command from $500 to over $1000. It has been estimated that $75,000 to $100,000 worth of pearls has been found between 1889 and the end of 1891, and during the past summer over $50,000 worth more.

During the summer of 1890, the Wisconsin pearl excitement extended to Manitowoc County in the same State, especially on Killsnake and Mud Creeks, the north and south branches of the Manitowoc River, and numerous small lakes that lie in Calumet County. As in the former times of excitement, hundreds of men, women, and children made trips to these creeks, the men and boys removing the shells from the river, while the women and girls opened them. From one to fifty pearls have been found in a single unio, and when numerous they were usually hinge pearls.

During August, 1890, the pearl-hunting fever extended along the Mackinaw River and the creeks running into it in McLean, Tazewell, and Woodford Counties, Ill. Pearls have also been found in the vicinity of Traer and Geneseo, on Wolf Creek, Iowa. A fine pink pearl was found near Walla Walla, Wash., and a number have been sold at Seattle, Wash.

In regard to this pearl excitement, which appears from time to time, it may be well to repeat the fact that it is advisable to search every creek and river where limestone is the country rock, since in nearly all instances the unios secrete pearls when this favorable condition exists.

Collections of Gems.

On the 3d of November, 1892, the new wing of the American Museum of Natural History was formally opened. On the fourth (the geological) floor is

exhibited the Tiffany-Morgan collection of gems, which was shown in the American section of the Paris Exhibition in 1889. To this collection have been added the gems and gem minerals from the Spang collection, a recent addition to the Museum, and such specimens as the Museum possessed before. These are now displayed in four flat cases, properly arranged and labelled, and form perhaps the most complete gem collection on exhibition in any public museum.

During the summer of 1892, the Harvard University Mineralogical Collection, under the charge of Prof. Josiah P. Cooke and Dr. Oliver W. Huntington, has been greatly enriched by the addition of the munificent gift of James A. Garland, Esq., of New York, who presented to that institution the finer crystals and mineralogical specimens obtained by the writer on a trip to Maine in 1892, and on a trip to Russia and the region of the Ural Mountains, made in the interest of Messrs. Tiffany & Co., in 1891, also the famous Dr. A. C. Hamlin collection of Tourmalines from Maine.

IMPORTS OF DIAMONDS AND PRECIOUS STONES INTO THE UNITED STATES.

Years.	Precious Stones in Rough and Uncut. Value.	Precious Stones (Cut). Value.	Years.	Precious Stones in Rough and Uncut. Value.	Precious Stones (Cut). Value.	Years.	Precious Stones in Rough and Uncut. Value.	Precious Stones (Cut). Value.
1867....	$906	$1,317,711	1876 ...	$207,082	$2,411,968	1885....	$318,767	$6,326,881
1868 ...	484	1,062.009	1877 ...	123,297	2,113,892	1886....	300,226	9,306,074
1869....	585	1,997,305	1878....	99,679	2,973,919	1887....	286.072	10,731,534
1870....	9,442	1,769,828	1879 ...	123,047	3,875,804	1888....	296,197	10,259,049
1871....	993	2,349,738	1880....	178,567	6,705,692	1889....	204,450	12,123.448
1872....	92,093	2,934,288	1881....	285,005	8,330,061	1890....	513,611	12,540,646
1873....	216,850	2,956,190	1882....	542,366	8,353,512	1891....	975,772	11,769,663
1874....	213,250	2,163,091	1883....	373,397	8,550,818	1892 ...	1,032,869	....
1875. ..	244,438	3,235,663	1884...	375,564	6,534,139			

Foreign Gem Mines in 1892.

On the 22d of July the fourth general meeting of the Burmah Ruby Mines (Limited) was held in London. It was stated that the item of rent of the mines included a sum of £8,888 17s. 9d., representing the unpaid rent for four months to the last of February, 1892, and the directors had considered it necessary to notify the Government distinctly that, notwithstanding the low rate of exchange, unless the rental of the Ruby Mines was greatly reduced, they could not recommend the shareholders of the company to continue operations. Since then work has been carried on at the mines with greater energy than before, and one stone found is said to be finer than anything obtained there for years.

The company had already paid a rental of £60,000 and £70,000 could still be called from the shareholders, but the company did not wish to put all its resources into the pocket of the Government. It was proposed to make a call of 2s. 6d. a share. Whether these calls are to be continued, whether the mines are to be suspended, or whether a quantity of fine rubies will be found in the near future, remain questions in regard to the future of this gigantic company, whose mines are in a country where the white man cannot exist in comfort, and indeed scarcely at all.

Mr. W. S. Lockhart, formerly engineer to the Burmah Ruby Mining Company, has recently written to the *Financial News*, expressing his belief that the mines

might pay if they were worked properly. He considers the machinery far too heavy (a fact by no means new), and remarks that "it would only require twelve small plants capable of earning £1000 per month each, to meet the present rate of expenditure and pay a dividend."

The Sapphire and Ruby Company (Limited), having been in existence over two years in June, made its first report to the stockholders to the effect that 210,000 carats of gems had been received, but that no sales had been made. In the same month the North Burmah Ruby Company failed so completely, that it was turned out of its offices without even assets enough to pay the printing bill of the last stockholders' summons.

During 1891 a number of gem-mining companies were formed in Ceylon, but nearly all of them have suspended operations, although the South African mines have prospered under more intelligent management, and by the introduction of every modern and improved appliance in machinery, system of managing the miners, electric lighting, etc. Yet the same methods seem to have failed in Ceylon, Burmah, and Siam.

The De Beers Company (Limited) has maintained the price of diamonds during the past year, and has absorbed its new and apparently dangerous rival—the Premier Mine. The diamond market has been firm in prices, having neither advanced nor receded, the output having been regulated.

EXPORTS OF DIAMONDS FROM CAPE OF GOOD HOPE.

Year.	Carats.	Value.	Year.	Carats.	Value.
1884	2,263,734	£2,807,329	1888	3,841,937	£4.022,379
1885	2,440,788	2,489,659	1889	2,961,978	4,325,137
1886	3,135,061	3,504,755	1890	2,504,730	4,162,073
1887	3,692,265	4,126,288	1891		

PRODUCTION OF DIAMONDS AT THE DE BEERS CONSOLIDATED MINES, LIMITED, SINCE APRIL 1, 1888.

Year Ending March 31st.	Loads Hoisted	Loads Washed	Carats Found.	Value.	Carats per Load.	Value per Carat.	Cost per Load.	Loads on Floors, Close of Year.	Dividends Paid. Date.	Dividends Paid. Amount.	Dividends Paid. Equal to	Capital.
				£ s. d.		£ s. d.	s. d.			£ s. d.	%	£
1889	944,706	712,263	914,121	901,118 0 5	1.283	19 8¾	9 10½	476,403	1888	188,329 10 0	5	3,937,050
1890	2,192,226	1,325,400	1,450,605	2,330,179 16 3	1.09	1 12 6¾	8 10½	1,576,821	1889	394,786 10 0	10	3,948,955
										394,895 10 0	10	
1891	1,978,153	2,105,182	2,020,515	2,974,670 9 0	.96	1 9 6	8 8	1,449,792	1890	394,895 10 0	10	3,948,955
										394,895 10 0	10	
1892 June 30	3,338,553	*3,239,134	3,035,481	3,931,542 11 1	.92	1 5 6	7 4¾	1,624,803	1891	394,895 10 0	10	3,948,955
										493,619 7 6	12½	
									1892 June 30	493,619 7 6	12½	3,948,955

* And Du Toit's Pan and Ultfontein 454,278.

Totals 7,420,722 carats, valued at £10,148,210 16*s*. 9*d*. Dividends paid since 1888, £2,849.936 15*s*.

QUICKSILVER.

The quicksilver production of California for the year 1892 amounted to 27,993 flasks—exceeding the output for 1891, notwithstanding the fact that the New Almaden mine is fast declining. The increase was chiefly due to the greater output of the Napa Consolidated and the Great Western, although there was a general increase all along the line, with the exception noted. New Almaden still continues among the largest producers, but it has sadly fallen from its former glory, and the prospects for the future are reported to be very gloomy.

The new mines reported have been of the usual order, "great promise and little or no performance."

Table No. I. shows the production of California producers from 1850 to the end of 1892 and the value per flask for each year. Following this is given the number of tons roasted by the New Almaden Company to obtain its reported yield in flasks, showing also the percentage yield with its gradual decline from 36.7% in 1850 to 1.2% in 1891. The cost of mining and transportation, the total cost per ton roasted, and the total cost per flask obtained is reported for such years as the available data allow.

Table No. II. shows the San Francisco and London prices for quicksilver yearly from 1850 up to 1891 and monthly since then. It also shows the United States import duties for each period to indicate the extent to which the San Francisco quotation corresponds to the London quotation with the duty added. The average San Francisco price for 1892 was $38.80 per flask; London, £6 14s.

Table No. III. shows the consumption of quicksilver per ton treated for different years by well-known mines using the amalgamating process in the treatment of their silver and gold ores. This table gives interesting data, but the consumption of quicksilver is affected so greatly by careful management as well as by the character of the ore that its practical value may easily be overestimated.

The exports and imports for the United Kingdom are given by Messrs. Joseph Bennett Brothers of London as follows:

		1880	1891	1892
Imports from Jan. 1 to Dec. 31	bottles, about	59,410	62,770	56,990
Exports " " " "	" "	61,465	56,643	50,211
Imports for December	" "	688	1,262	663
Exports " "	" "	8,602	1,910	6,232
Price	per bottle, about	£9 5s.	£8	£6 5s.
Stock in London to Dec. 31 roughly calculated	bottles, about	27,500	23,500	22,000

Table No. IV. shows the world's production since 1880, and gives a comparison of the American and foreign production. It also shows the exports and imports of the United States for the same years.

I.—QUICKSILVER PRODUCTION OF CALIFORNIA MINES BY FLASKS (76.5 LBS. EACH).

Year.	New Almaden. *a*	Napa Consolidated.	Great Western.	Great Eastern.	Ætna.	Sulphur Bank.	New Idria.	Redington.	Gaudalupe.	Pope Valley.	Various Mines.	Total.	Value per Flask.	New Almaden Mine. Tons Ore Roast'd	Per cent Yield.	Dividends.	Costs per Ton. Mining, etc.	Total *f*	Cost per Flask. *e*
1850..	23,875	....	....	....	....	....	Production from 1858 to 1866 = 17,455 flasks, included in production of various mines. No yearly reports obtainable.	....	Yearly production previous to 1875 not obtainable (estimated at 20,000 flasks), included in production of various mines.	....	....	23,875	$99.45	2,485	36.74	....	....	....	....
1851..	19,921	....	....	....	....	....		....		....	....	19,921	66.93	2,322	32.82	....	....	....	....
1852..	18,035	....	....	....	....	....		....		....	4,009	22,134	58.32	2,420	28.51	....	....	....	....
1853..	26,325	....	....	....	....	....		....		....	....	26,325	55.45	3,724	27.04	....	....	....	....
1854..	31,860	....	....	....	....	....		....		....	....	31,860	55.45	4,555	26.76	....	....	....	....
1855..	28,083	....	....	....	....	....		....		....	3,858	31,941	53.55	5,178	20.75	....	....	....	....
1856..	26,002	....	....	....	....	....		....		....	2,862	28,864	51.65	5,150	19.31	....	....	....	....
1857..	39,935	....	....	....	....	....		....		....	....	39,935	49.73	7,435	20.54	....	....	....	....
1858..	....	....	....	....	....	....		....		....	5,239	5,239	47.82	....	....	....	....	....	....
1859..	....	....	....	....	....	....		....		....	11,706	11,706	63.13	....	....	....	....	....	....
1860..	....	....	....	....	....	....		....		....	2,939	2,939	53.55	....	....	....	....	....	....
1861..	34,765	....	....	....	....	....		....		....	571	35,336	42.10	....	....	....	....	....	....
1862..	40,391	....	....	....	....	....		444		....	1,885	42,720	36.35	6,912	19.96	....	....	....	....
1863..	29,531	....	....	....	....	....		852		....	6,876	37,259	42.07	7,641	20.22	....	....	....	....
1864..	42,489	....	....	....	....	....		1,914		800	2,286	47,489	45.90	5,939	19.02	....	....	....	....
1865..	47,194	....	....	....	....	....		3,545		....	2,261	53,000	45.90	11,639	13.96	....	....	....	....
1866..	35,150	....	....	....	....	....	6,525	2,254		....	2,621	46,550	51.63	15,974	11.30	....	....	....	....
1867 .	24,461	....	....	....	....	....	11,493	7,862		....	3,184	47,000	45.90	13,443	10.00	....	....	....	....
1868..	25,628	....	....	....	....	....	12,180	8,686		1,122	112	47,728	45.90	13,012	7.19	....	....	....	....
1869..	16,898	....	....	....	....	....	10,315	5,018		1,580	....	33,811	45.90	14,703	6.67	....	....	....	....
1870..	14,423	....	....	....	....	....	9,888	4,546		1,220	....	30,077	45.90	12,729	5.08	....	....	....	....
1871..	18,568	....	....	....	....	....	8,180	2,128		1,970	840	31 686	57.37	10,549	5.23	....	....	....	....
1872..	18,574	....	....	....	....	....	8,171	3,046		1,830	....	31,621	63.10	11,017	6.45	....	....	36.38	18.14
1873..	11,042	....	340	....	....	....	7,735	3,294		1,955	3,276	27,642	65.98	10,708	6.63	....	....	42.73	22.86
1874..	9,084	....	1,122	....	....	573	6,911	6,678		1,645	1,743	27,756	80.32	8,665	4.89	....	....	46.01	28.79
1875..	13,648	....	3,384	412	....	5,372	8,432	7,513	3,342	1,940	6,207	50,250	105.18	11,727	2.96	....	....	42.08	43.85
1876..	20,549	573	4,322	387	....	8,367	7,272	9,183	7,381	300	16,740	75,074	84.15	15,553	3.36	....	....	32.52	33.72
1877..	23,996	2,229	5,856	505	....	10,993	6,316	9,399	6,241	1,060	12,801	79,396	44.00	16,658	4.72	....	....	26.08	19.52
1878..	15,852	3,049	4,963	1,366	....	9,465	5,138	6,686	9,072	1,075	7,214	63,880	37.30	18,616	4.93	....	....	23.47	16.92
1879..	20,514	3,605	6,333	1,455	....	9,240	4,425	4,516	15,540	1,325	6,722	73,684	32.90	18,471	3.28	....	....	21.47	22.47
1880..	23,465	*b*4,416	6,442	1,279	....	10,706	3,209	2,139	6,670	275	1,325	59,926	29.85	27,533	2.85	....	....	17.04	22.00
1881..	26,060	*b*5,552	6,241	1,065	....	11,152	2,775	2,194	5,228	....	584	60,851	30.35	30,677	2.93	....	$8.11	14.74	18.55
1882..	28,070	*b*6 842	5,179	2,124	....	5,014	1,953	2,171	1,138	....	241	52,732	28.97	32,071	3.11	$525,391	7.74	11.57	11.98
1883..	29,000	*b*5,890	3,869	1,669	....	2,612	1,606	1,894	84	....	101	46,725	28.43	36,074	2.98	280,313	9.93	14.40	17.87
1884..	20,000	1,376	3,292	332	2,931	890	1,025	881	1,179	....	7	31.913	26.83	38,581	2.88	....	8.84	12.65	16.13
1885..	21,400	2,197	1,144	446	1,309	1,296	3,469	385	35	....	392	32.073	29.34	39,626	1.93	128,739	9.52	12.80	24.19
1886	18,000	1,769	1,949	735	3,478	1,449	1,406	409	....	....	786	29.981	30.52	39,535	2.07	....	11.62	15.38	27.42
1887..	20.000	2,694	1,446	673	2,880	1,890	1,490	689	....	....	*c*2,235	33,997	35.44	40,699	1.69	118,011	10.54	13.63	29.14
1888..	18,000	4,065	625	1,151	959	2,164	1,320	126	....	....	4,840	33,250	38.73	32,076	2.38	128,739	12.17	16.01	23.10
1889..	13,100	4,590	556	1,345	....	2,283	980	812	....	....	*d*2,818	26.484	40.11	28,663	2.40	289,663	12.51	18.24	27.85
1890..	12.000	3,429	1,334	1,046	931	1,608	977	505	....	....	1.096	22,926	45.71	28,888	1.73	193,109	10.77	14.90	31.38
1891..	8.200	4,080	2,066	1,759	1,049	1,375	870	442	....	....	3,045	22.886	52.01	22,615	2.02	257.478	14.62	17.97	28.20
1892..	5.563	5,680	5,867	1,630	1,592	1,393	848	728	....	....	4,692	27.993	43.29	25,584	1.22	53,641	....	15.58	46.57

(*a*) In order to show the relation between tons of ore roasted and flasks of quicksilver obtained, the production of New Almaden is divided into fiscal years, as follows: For 1850–56 the production is from July to June, inclusive; for 1857 from July, 1857, to October, 1858; for November, 1858, to January, 1861, no production is reported; for 1861–62 the production is from February to January, inclusive; for 1863 from February to December, inclusive; since 1863 the fiscal year coincides with the calendar year. (*b*) Including Ætna. (*c*) Including 65 flasks from Oregon. (*d*) Including 20 flasks from Oregon. (*e*) This cost is obtained by deducting amounts to credit miscellaneous and ore account increased. (*f*) This cost is obtained by charging tons roasted with the total expenditures.

II.—AVERAGE PRICE PER FLASK QUICKSILVER, SAN FRANCISCO AND LONDON, WITH UNITED STATES IMPORT DUTIES FOR EACH PERIOD.

Year.	San Francisco.	London.	Duty.	Year.	San Francisco.	London.	Duty.	Year.	San Francisco.	London.	Duty.	Year.	San Francisco.	London.	Duty.
	$	£ s. d.	%		$	£ s. d.	%		$	£ s. d.			$	£ s. d.	Per lb.
1850	99.45	14 1 3	20	1864	45.90	8 5 0	10–15	1878	32.90	6 16 3	13.5%	1892, Jan...	42.45	7 6 6	10 cts
1851	66.93	13 0 0	20	1865	45.90	7 18 9	10–15	1879	29.85	7 6 3	13.5	Feb...	39.75	7 0 3	Do.
1852	58.32	10 8 9	20	1866	51.63	7 8 9	10–15	1880	30.35	6 17 3	13.5	Mar...	40.45	6 16 0	Do.
1853	55.45	8 8 9	20	1867	45.90	6 18 0	15	1881	28.97	6 6 8	13.5	Apr...	39.45	6 16 7	Do.
1854	55.45	7 10 0	20	1868	45.90	6 16 6	15	1882	28.43	5 19 0	13.5	May ..	39.20	6 16 10	Do.
1855	53.55	6 13 9	20	1869	45.90	6 16 6	15	1883	26.83	5 7 3	10	June..	39.45	7 1 3	Do.
1856	51.65	6 10 0	20	1870	57.37	8 8 0	15	1884	29.34	5 10 4	10	July..	39.45	6 18 3	Do.
1857	49.73	6 10 0	15	1871	63.10	10 10 0	15	1885	30.52	5 17 4	10	Aug ..	37.45	6 9 6	Do.
1858	47.82	7 7 6	15	1872	65.98	11 10 0	13.5	1886	35 44	6 9 7	10	Sept..	36 45	6 4 3	Do
1859	63 13	7 2 6	15	1873	80.32	16 0 0	13.5	1887	38.73	7 8 2	10	Oct...	36.45	6 6 3	Do.
1860	53.55	7 0 0	15	1874	105.18	22 10 0	13.5	1888	40.11	8 1 11	10	Nov ..	37.95	6 7 3	Do.
1861	42.10	7 0 0	10	1875	84.15	16 18 9	13.5	1889	45.71	8 11 0	10	Dec...	36.95	6 5 3	Do.
1862	36.35	7 0 0	10	1876	44.00	9 18 9	13.5	1890	52.01	9 5 0	10 cts. lb.	Average for			
1863	42.07	7 0 0	10	1877	37.30	8 6 3	13.5	1891	43.29	8 0 2	Do.	year......	38.80	6 14 0	Do.

III.—CONSUMPTION OF QUICKSILVER PER TON OF ORE WORKED, VARIOUS MINES.

Year.	Mine and Locality.	Tons of Ore Treated.	Lbs. per Ton.	Year.	Mine and Locality.	Tons of Ore Treated.	Lbs. per Ton.
1889....	Bimetallic, Mont..............	23,215	1.87	1889....	Lexington, Mont.......	26,361	.51
1889....	Elkhorn, "	8,712	1.54	1889 ...	Ontario, Utah..............	34,733	1.02
1887....	Hope "	8,091	.98	1888-89.	Empire, Cal.................	......	.06
1888....	" "	8,962	1.03	1888 ..	North Star, Cal............	17,259	.05
1889....	" "	6,634	1.33	1889 .	" " "	20,525	.05
1885....	Drumlummon, Mont..........	46,545	1.39	1880-90.	Idaho, "	278,830	.03
1886....	" "	50,235	1.20	1880....	Comstock Lode, Nevada. ..	130,578	1.89
1887....	" "	48,434	.65	1881....	" " "	47,890	1.91
1888 ...	" "	21,503	.26	1882....	" " "	81,110	1.76
1889....	" "	38,638	.49	1883....	" " "	95,993	1.84
1884-89.	Granite Mt., "	120,000	.80	1884....	" " "	83,120	1.90
1886-89.	Blue Bird, "	103,076	.83	1885....	" " "	78,689	1.68
1883....	Lexington, "	20,281	.82	1886....	" " "	192,837	1.93
1884....	" "	22,138	.59	1887....	" " "	159,666	2.43
1885....	" "	20,749	.78	1888....	" " "	195,203	2.13
1886....	" "	21,379	.31	1889....	" " "	202,997	1.86
1887....	" "	23,789	.41	1889....	Treadwell, Alaska	218,000	.01
1888....	" "	24,594	.55	1880-90.	Homestake, S. D............	2,159,011	.01

IV.—WORLD'S QUICKSILVER PRODUCTION IN FLASKS OF 76.5 LBS.*

Year.	United States.	Spain.	Austria.	Italy.	Total Foreign.	Grand Total.	United States Imports and Exports.	
							Imports, Flasks.	Exports, Flasks.
1880.........	59,926	45,322	10,510	3,410	59,242	119,168	1,536	37,210
1881..	60,851	44,989	11,333	3,712	60,034	120,885	1,823	35,107
1882..........	52,732	46,716	11,663	4,060	62,439	115,171	7,867	33,875
1883..........	46,725	49,177	13,152	5,974	68,303	115,028	20,431	30,072
1884....	31,913	48,098	13,967	7,743	69,808	101,721	1,798	7,370
1885..........	32,073	45,813	14,123	6,873	66,809	98,882	3,390	6,302
1886..........	29,981	51,199	15,689	7,279	74,167	104,148	8,288	6,091
1887...	33,997	53,276	15,428	7,076	75,780	109,777	5,525	11,394
1888	33,250	51,872	15,689	9,831	77,392	110,642	1,748	10,684
1889....	26,484	49,477	16,414	11,165	77,056	103,540	4,494	5,111
1890	22,926	50,202†	15,709	13,021	78,730	101,656	10,564	2,082
1891..........	22,886	47,993†	16,536	9,570	73,661	96,562	1,631	3,739

* Quicksilver is also produced in Borneo, Servia, Russia, and Mexico, but accurate returns are not available.

† Flask = 76.5 lbs. = 34.7 kilos.

The Quicksilver Mines of Mexico, while not altogether devoid of promise, have as yet added but little to the world's supply of that metal, although there would be a good domestic demand in the patio process for all produced.

A quicksilver deposit near Arichuivo, in the state of Chihuahua, was purchased by American capitalists in 1892. This property was but slightly developed, and the production had been small. The deposit consists of fine seams of cinnabar in porphyry. The Guadalcazar mines have been worked by the English Company, but so far the results have been unsatisfactory, although large quantities of good grade ore are claimed to be in sight. Here quicksilver ores occur in a belt nearly 40 miles long lying to the northeast of Guadalcazar. The deposits occur mainly as layers in the limestone, but irregular networks of vein or stock-werks are also found.

The chief ore is cinnabar, often hepatic, and sometimes accompanied by the seleno-sulphide guadalcazarite. Calcspar and fluorspar are the gangue minerals.

In the state of Guerro, cinnabar deposits are worked on a small scale at Huitzuco, about 50 miles north of Tixtla. The deposits here are pockets of various dimensions and layers; veins, however, are known to exist in disturbed metamorphic slates and limestones. The deposit of Teposcolula is a vein between metamorphosed limestone and slates. The ore, which is also argentiferous, is livingstonite, a sulphide of antimony containing mercury. At Chilapa, San Onofre, San Felipe, Guanajuato, Loma de Encinal, Guaneceri, San Andres, and other localities small occurrences of cinnabar are known to exist, but not in sufficient quantity for profitable extraction.

SALT.

By F. E. Engelhardt, Ph.D.

The salt resources of the United States are either solid or brine. Of the former two kinds exist—the rock-salt deposits, and the salt incrustations of the high plains in the regions west of the Rocky Mountains. Among salt solutions we have, first, the vast extent of ocean* along our coast; and, secondly, the salt lakes and salt springs. The production of salt from these sources, both for domestic and for technical purposes, is accomplished in three ways—by mining, by solar evaporation, and by artificial evaporation.

Rock Salt.—The rock-salt deposits in the United States are of sedimentary origin, deposited from their solutions in water by evaporation. They occur in various geological ages.

This process is now going on in some of the well-known salt lakes; that is, where there is an almost constant deposition of salt at their bottoms in consequence of their being without outlets, and the streams entering them carrying not only salt in solution, but bringing less water to them than the annual evaporation from their surfaces amounts to. All the theories given in explanation of the formation of rock-salt deposits have, according to Prof. Posepny, one point in common, viz., that all these easily soluble combinations became solid masses only in places where the water could be removed from them by evaporation, and, when once solidified, remained so only when no solvent had access to them. In his opinion they do not account for the immense thickness of some known salt beds (Stassfurt, 1800 ft. thick; and Sperenberg, near Berlin, 3600 ft.), since, if we consider that the water of the ocean contains 3.5% of saline matter, a column of sea-water 100 meters in height represents 1.4 meters of saline matter, and the greatest known depth of the ocean (13,620 meters) would represent but 191 meters of saline matter. He therefore has advanced the theory that the salts of the ocean are transported inland by the winds, and thus accounts in part for the large rock-salt deposits and the salt found on the high plains.

Absolutely pure rock salt is rarely found, and then only in very small quantities. There are present or associated with it, according to its geological age, the

* One hundred parts of the water of the Pacific Ocean contain 3.47 parts of solid matter; 100 parts of the water of the Atlantic Ocean, 3.55 parts solid matter.

chlorides of potassium, calcium, and magnesium ; the sulphate of lime, either as gypsum (sulphate of lime with the water of crystallization), or as anhydride (sulphate of lime without the water of crystallization); the sulphate of magnesia, or epsom salt; and the sulphate of soda, or glauber's salt. Iodides and bromides are often found, but usually in very slight traces. Besides these there are shales, clays, marls, sandstones, etc., either intermixed with the rock salt or present in seams or layers.

It was not until the year 1862 that the first bed of rock salt of which use has been made by mining was discovered in the United States. The existence of salt licks on Petit Anse, an island in the southwestern part of Louisiana, has been known since 1791. During the late civil war, salt becoming very scarce in the Southern States, the old holes or salt wells on the island used during the war of 1812 were brought into requisition, and on cleaning out one of them to obtain a more copious supply of brine a hard material was encountered, which proved to be a layer of rock salt, about 16 ft. below the surface of the ground. This discovery was made by the late Col. John Marsh Avery, on May 11, 1862. The salt deposit is about 150 acres in extent, from 16 to 25 ft. below the ground, somewhat triangular in shape, and, so far as known, 2500 to 2600 ft. wide. From borings made with a diamond drill some three years ago, it was learned that this bed is over 1000 ft. in thickness. At this depth the borings were discontinued. The most singular fact about this salt deposit is that it stands, so to say, on its edge. The stratification is nearly perpendicular from east to west, indicating an upheaval,* and what was its original depth is now its width. It is at present considered to belong to the Tertiary period, though perhaps its true position can only be known with certainty when the underlying formation is reached. The salt, according to Prof. Charles Goessmann, occurs as "a solid crystalline rock of a saccharodial texture, the individual crystals being indistinctly aggregated and interspersed with microscopic crystals of gypsum." † This salt is very pure, and if it were not for the peculiarity that it "cakes" after being ground, it would years ago have had a much greater and more extended market, especially as a table salt. This difficulty, however, according to the manager of the works, was overcome last year.

The next rock-salt discovery, and one which led to the sinking of four shafts, was made June 20, 1878, in Wyoming County, New York, in boring for petroleum, at the depth of 1270 ft. The bed was found 70 ft. thick. This discovery was followed by the sinking of a number of wells in Wyoming, Genesee, and Livingston counties in the following years. Rock salt having been found in the last-named county, both at Piffard and at Greigsville, the sinking of the first shaft was commenced by the Retsof Mining Company and finished in 1885, and is 1018 ft. deep. About a mile west of the Retsof shaft a second is being sunk, which will reach the salt bed in about a month. Another shaft has been sunk two miles south of Le Roy by the Lehigh Salt-mining Company, of Scranton, Pa.; it is about 825 ft. deep. The fourth shaft is situated at Livonia, Livingston County, and has a depth of 1430 ft. These four shafts will be capable of furnishing 2000

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* E. E. Rapley, in *The Soils and Products of Southwestern Louisiana*, United States Department of Agriculture, Washington, 1884.

† Report of the American Bureau of Mines on the rock-salt deposits of Petit Anse, New York, 1867.

tons of rock salt daily. This salt, when taken from the shafts, is of a gray color, due to the presence of finely disseminated dark-gray clay, which, on solution of the salt, sinks, leaving a perfectly clear brine above. The salt is mainly an aggregation of not quite perfectly developed crystals, and when the lumps are broken the cleavage of many of these crystals is very marked ; the fracture is conchoidal. Large pieces of the salt show stratification.

This rock-salt bed, which furnishes all the salt works in the western part of the State with brine, is in the Upper Silurian. It extends east and west, according to our present knowledge, from Madison County to Lake Erie, and north and south from Le Roy to Castile, therefore probably underlying portions of Madison, Onondaga, Cortland, Tompkins, Cayuga, Seneca, Ontario, Yates, Livingston, Genesee, Wyoming, and Erie counties. The salt stratum is over 100 ft. thick. In one well below the Tully Hills, Onondaga County, it had a thickness of 318 ft., and in another well 228 ft. It extends under Lake Erie, and underlies the northern counties of Ohio and Indiana, the entire peninsula of Michigan, and the western part of the Province of Ontario along Lake Huron and the St. Clair River. In some parts of this salt deposit—underlying thousands of square miles—we find the salt occurring in one vein, or in two, three, four, five, six, or even in seven veins, with layers of shales or clay between them of varying thickness, and at different depths below the surface. To explain the former, it is necessary to transfer ourselves to one of the large salt lakes covering many hundred miles of surface. During the hot summer months the evaporation is greatly in excess of the amount of water entering the lake. As evaporation progresses, the less soluble salt, viz., the sulphate of lime, separates first from the water as gypsum, forming a layer over last year's deposit, followed, as soon as the point of saturation of the salt is reached, by the latter in the form of a deposit, which will continue to increase with the advancing evaporation until a change in the weather takes place. Heavy rains occur, and the rain-water descends in large quantities from the surrounding hills, carrying along with irresistible force all the loose material on its way into the usually dried-up streams and brooks, which in turn discharge the water, heavily laden with mud, into the lake. The heavier material settles nearest to the lake shore on the lately deposited salt, forming a more or less thick layer, which in time hardens to shale or marl, while the lighter, mechanically suspended particles are carried farther out into the lake, according to the force of the incoming waters. They also finally settle, forming a much thinner layer. Some parts of the lake, if it is a very large one, may not be reached by the suspended matter, and there no sediment is formed over the salt below. Since the rain-water is much lighter than the saturated brine of the lake, they mix but slowly, the fresh water floating over the brine. Heavy frosts occur, and soon a strong crust of ice covers the surface of the entire lake. With the returning warm weather, rains again set in, carrying a fresh load of loose material toward and onto the ice of the lake, where the ice keeps it from sinking to the bottom until it becomes too weak to bear the load, and then both disappear below the surface. Thus also considerable quantities of this débris may be carried by the floating ice into places where there was none before. Evaporation, in consequence of the elevated temperature and the ever-moving air, soon causes the lake water to become saturated with sulphate of lime, which it dissolves from the soil and suspended material. It sepa-

rates, forming a new layer over the bottom of the lake in the form of gypsum, to be followed by another layer of salt again as evaporation progresses, and so the process goes on.

The third rock-salt discovery, which caused a remarkable development in a very short time, was that at Ellsworth County, Kansas, in August, 1887, where a bed of rock salt, 140 ft. in thickness, was found 730 ft. below the surface. This was soon followed, at Hutchinson, by the discovery of a 250-ft. bed of salt 450 ft. underground. Next came the discovery of 200-ft. rock salt at Kingman, at a depth of 665 ft., followed by the discovery, on Dec. 2, 1887, of a bed 250 ft. in thickness, 785 ft. below the surface, at Lyons. The discovery of 75-ft. rock salt at Anthony, 925 ft. below the surface, was the last of the year 1887. During the year 1888 rock salt was found at Nickerson; at Great Bend, with a thickness of 125 ft., and at Sterling, with a thickness of 198 ft. There are at present four salt shafts in Kansas—two at Kingman, one at Lyons, and one at Kanopolis—with a daily capacity of about 2000 tons. Thus we have now in the United States 9 salt shafts, with a total capacity of 4500 tons per day.

The average Kansas rock salt does not differ materially in appearance from the New York rock salt. Geologically this salt deposit is found at the base of the Triassic, according to Prof. Robert Hay, and underlies portions of Ellsworth, Barton, Rice, Reno, Kingman, and Harper counties. Rock salt has also been found in Southwestern Virginia in the Preston Valley. In one well over 300 ft. of rock salt were penetrated, though the deposit is considered to be but local by Prof. J. P. Lesly, and probably belongs to the Tertiary. It is accompanied by gypsum and marls, and in appearance resembles the English rock salt.

In Nevada rock salt is obtained in Churchill, Washoe, and Elko counties, and is mainly used in silver metallurgy. The same is true in regard to the Utah, California, and Arizona rock salt.

Salt Incrustations.—The salt incrustations which are especially found on the high arid plains of Colorado, Utah, Nevada, New Mexico, Arizona, etc., are of local interest only, and the salt is used for home consumption solely. They are usually the remnants of former shallow salt lakes and salt marshes.

Sea Salt.—Sea salt is made in Massachusetts at South Dartmouth, Bristol County, and at East Dennis, Barnstable County, though the quantity is at present very small. The great bulk of sea salt is obtained in California in the Bay of San Francisco, especially in the county of Alameda, where there are at present over 25 works. In Los Angeles and San Diego counties, bordering on the Pacific, there are also several works in which sea salt is produced. It is all used for home consumption.

Salt Lakes.—The most important salt lake in the United States is the Great Salt Lake of Utah, which is 75 miles long by 30 miles wide. A remarkable feature of this lake is the preservation of its ancient shore lines, which are about 900 ft. above the surface of the present lake, and from which the volume of the ancient lake has been calculated to have been 280 times greater than the present one. Since the year 1858, when Stansbury made his observations, the surface of the lake has risen about 12 ft. The water is said to contain about 20% of pure salt and 2% of other saline matters. The main salt works which furnish salt by

solar evaporation are situated in the counties of Davis, Salt Lake, Box Elder, and Weber, which border on its shore, and in Sevier County.

Nevada has several salt lakes east of the Sierra Nevada—viz., the Humboldt, Carson, Pyramid, and Walker lakes. The most important salt works are near the Sand Spring Marsh and Big Salt Valley, in Churchill County; Silver Peak and Columbus, in Esmeralda County; Reno, in Washoe County; and Huntington, in Elko County. The Utah and Nevada salt is almost entirely used for local consumption, especially in chlorinating silver ores.

In California there are salt lakes in Tulare County, and a dry lake near the Taheechaypah Pass, in the Sierra Nevada, from which salt is obtained.

In Texas there is a lake called La Sal del Rey, about one mile in length and five miles in circumference, with a depth of water of from three to four feet, entirely underlaid with a solid salt crust of remarkable purity (99%), which furnishes salt for local consumption.

Brines.—The brines of the United States which serve to-day for the manufacture of most of the salt used for domestic purposes are distributed over a very large territory, and they occur in several geological formations, from the Silurian upward. As they come from the bowels of the earth they are often highly charged with carbonic-acid gas, and in consequence contain traces of bicarbonate of iron and sometimes of lime, both of which will separate almost entirely as soon as the free carbonic acid, the solvent, has escaped and the iron become oxidized. Other brines are often charged with carburetted hydrogen to such an extent that the gas has been used as a fuel for their evaporation. Even petroleum is found associated with some brines. Among the other impurities, sulphate of lime, or gypsum, is the most important, since it prevents the continuous manufacture of salt by artificial heat in consequence of its tendency to bake on highly heated surfaces, forming a constantly increasing coating over them. This coating adheres with such tenacity that it is impossible to remove it sufficiently while the works are in operation. Being a very bad conductor of heat, it entails a great expenditure of fuel if the operation is continued beyond a certain time; hence the necessity of interrupting the process to remove these scales. Several methods have been proposed to precipitate the sulphate of lime from the brine before the salt separates, either by superheating the brine or by chemical means; but thus far the expense incurred by these methods has been out of proportion to the benefits derived; hence the practical removal of sulphate of lime from salt brines is even now the most important problem in connection with the manufacture of salt by artificial heat.

Though chloride of potassium occurs in many brines in small quantities, it is so near in its main characters to the chloride of sodium or salt that no particular attention is paid to it in the practical manufacture of salt. Chloride of calcium and magnesium, when present in salt brines beyond mere traces, if not properly removed from the manufactured salt, give to the latter a peculiar sharp and bitter taste, and cause the salt to keep damp, as they attract moisture out of the air. Certain brines contain, instead of chloride of calcium, sulphate of magnesia and soda, which require special attention for their proper removal on the part of the manufacturer in order to make a good commercial article.

It is evident from what I have stated before that there must be two kinds of

salt brines and rock salt. One class invariably contains chloride of calcium, while the other has sulphate of magnesia and soda in its composition, making the presence of chloride of calcium impossible. It is believed that the composition of the waters of the ocean before the Tertiary period differed materially from that of the present ocean in that the former contained chloride of calcium, while the latter has sulphate of magnesia and soda. Prof. Charles A. Goessmann, in his "Contributions to the Chemistry of Common Salt," says: "We do not hesitate to speak in general terms of a primitive ocean—of an ante-Tertiary or Silurian ocean, and of a post-Tertiary ocean, including in the latter that of the present day." *

So far as I am informed, rock salt has been found in the Upper Silurian in the following places in the State of New York: at Morrisville, in Madison County; Tully, Onondaga County; Ithaca and Ludlowville, Tompkins County; and Aurora, Cayuga County. Livingston has wells to the rock-salt deposit at Dansville, Mount Morris, Cuylerville, Livonia, Lakeville (on Conesus Lake), Piffard, Greigsville, and York. In the Wyoming Valley, Wyoming County, rock salt has been penetrated at Castile, Silver Spring, Perry and Silver Lake, Rock Glen, Warsaw, Wyoming, and Pearl Creek. In Genesee County there is the Lehigh shaft and a well about two miles south of Le Roy, besides the wells at Le Roy and Pavilion. East Aurora is the only place in Erie County where rock salt has been found. In Northern Ohio the Silurian rock-salt deposit has been struck in Cuyahoga County near Cleveland, on Lake Erie, in Medina County at Wadsworth, and in Summit County at Akron. The salt formation of the Upper Silurian in Michigan has been reached and rock salt found along the St. Clair River and St. Clair Lake and in the counties of Bay, Alpena, Manistee, Mason, and Muskegon. In the Province of Ontario it occurs along the shore of Lake Huron at Kincardine, Goderich, Clinton, Seaforth, Stapleton, etc., and at a number of other places, especially near the St. Clair River and St. Clair Lake.

The thickness of the salt stratum and its depth from the surface in these various localities are very variable. At Morrisville it is 12 ft. thick and 1259 ft. below the surface. At Tully, in 30 wells it varies from 25 to 318 ft., at a depth of from 974 to 1465 ft. At Ithaca the seven rock-salt beds have a thickness of 248 ft., and the first salt bed is reached 2244 ft. below the surface. In the Genesee Valley the rise of ground is from north to south, and the dip of the formation about 40 ft. per mile in the same direction; which facts explain the difference of the depths from the surface to the salt, which in the 20 miles is from 750 to 2100 ft., and the thickness of the salt from 40 to 93 ft. In the Wyoming Valley, which runs nearly parallel with the Genesee, there is a depth to the salt in the 25 miles of from 610 to 2370 ft., and a thickness of salt of from 12 to 85 ft. The dip of the formation and the rise of the ground are about the same as in the Genesee Valley.

In the first well at Cleveland, Ohio, the rock-salt stratum was reached at 1990 ft., having a thickness of 239 ft., with four salt beds, while in the Van Campen well at Wadsworth, Medina County, the first salt bed was struck at 2575 ft., with a thickness of 240 ft. of the salt-bearing stratum and 6 rock-salt beds.

The rock-salt deposits in the Upper Silurian in Michigan were reached at Marine City at 1633 ft., with 115 ft. of salt below, and at St. Clair at 1635 ft., with

* *American Journal of Science and Art*, January, 1870.

35 ft. of salt. Salt has also been found at Caseville, in Huron County, at 1164 ft., and at Bay City, on Saginaw Bay, at 2085 ft., with rock salt of 115 ft. thickness. Manistee has 34 ft. of salt at 2000 ft. depth, and Muskegon, in the Mason well, 50 ft. of salt at 2200 ft. depth.

The next formation in age and extent which is saliferous is the Carboniferous. A great part of the Michigan brines, especially those of East Saginaw and vicinity, come from the Napoleon sandstone which underlies the Carboniferous and serves as a reservoir for these brines. The extent of this formation in Michigan is given by the late Prof. Alexander Winchell at 17,000 sq. miles. The same formation is thought to furnish the brines of the Ohio Valley and those of Western Pennsylvania. The coal measures are supposed to be the source of most of the brines at Bay City in Michigan, of the valley of the Great Kanawha River in West Virginia, and of the State of Indiana.

Absolutely pure salt consists of 39.3 parts of sodium and 60.7 parts of chlorine. Native rock salt occurs either crystallized or massive, granular, and occasionally columnar. It crystallizes in the isometric system, generally in cubes, very rarely in octahedrons, and has a perfect cubical cleavage. Its hardness is given at 2.5, its specific gravity at from 2.1 to 2.257. Its luster is vitreous and its streak white. In regard to color, it is found colorless, white, yellow, red, brown, or even blue. To light it is transparent to translucent. The fracture is conchoidal. It is the most perfectly transparent body known to heat. Thus of 100 parts of heat given out by a Locatelli lamp a rock-salt plate allows 92% of heat to pass through, while a plate of crystallized gypsum of the same thickness permits only 14 parts to pass. When the source of heat is a blackened sheet of copper raised to a temperature of 752° F. by an alcohol lamp the salt plate allows 92% to pass through, while a gypsum plate allows none to pass. This proves the great importance of having the heated surfaces of the pans, kettles, steam-pipes, etc., free of sulphate of lime or gypsum. Chemically pure salt has a pure saline taste. Artificially made salt always decrepitates, due to a slight trace of moisture mechanically inclosed. It melts at red heat and volatilizes at a higher temperature. Its specific heat, according to Regnault, is 0.21401. The solubility is given slightly different by different authors. According to Poggiale, 100 parts of water dissolve at 32° Fahr. 35.52 salt, and at the boiling point, or 229.5° F. (of a saturated solution of salt), 100 parts of water dissolve 40.35 salt. Fuchs holds that 37 parts of salt are soluble in 100 parts of water at all temperatures. In 100 parts of a saturated salt solution are contained 26.5 of salt, and its specific gravity is 1.205. When salt separates from a solution at ordinary or higher temperature it crystallizes always in cubes, which often aggregate in the form of four-sided pyramids with the apex down in the brine—the so-called hopper-shaped crystals.

The manufacture of salt from brines by solar evaporation is carried on in shallow wooden vats, usually provided with movable wooden covers, which serve as a protection during winter and rainy weather. The Syracuse works, the most extensive in the United States, have an evaporating surface of over 12,000,000 sq. ft. Other localities are Bay and Saginaw counties in Michigan, Van Zandt and Colorado counties in Texas, and Solomon City and Salina, Saline County, Kan., besides some smaller works in other States. The methods of manufacture of salt by artificial heat and direct fire are the kettle method of Onondaga County in New

York, and the pan method of Western New York, Michigan, Kansas, etc. Steam s used in the grainers and a few vacuum pans of Michigan, Western New York, Kansas, etc. The works in the Ohio Valley and West Virginia have a method of their own which is well adapted for the weak brines usually operated on. The total amount of salt produced on the Onondaga Salt Reservation since 1797 is 71,284,515 barrels; in Michigan since 1868, 60,614,464 barrels of 280 lbs. each.

The expense of making salt depends on the strength and quality of the brine employed, on the kind of fuel and its price and quality, on the kind of labor and the cost of the same, on the weather, on the wear and tear and the original cost of the plant, and, finally, on the quality and quantity of the salt made. From these considerations it is evident that the manufacturing price per barrel or ton of salt is different in every locality and individual salt work. In Syracuse a ton of anthracite dust will produce from 8 to 10 barrels of salt; in the western part of the State from 13 to 15 barrels. In West Virginia and the Ohio Valley the product is 5 barrels, while in Michigan from 14 to 15 barrels are made with the same coal. To make a barrel of ordinary common fine salt, including barrel, costs in Syracuse from 55c. to 60c., in Western New York from 45c. to 50c., and in Michigan from 25c. to 30c., where wood, which is the offal from saw-mills, has been used as fuel.

For artificial evaporation anthracite dust, bituminous coal, and wood have served as fuel. No important improvements in the manufacture of salt were made during 1892. The amount of salt used in the United States per inhabitant is about 56 lbs., or one bushel, while our present productive capacity greatly exceeds this. Michigan, with 112 salt blocks and 4000 solar-salt covers, can produce 5,425,000 barrels. New York, with 100 salt blocks and 43,000 salt covers at Syracuse, 30 pans, including 6 vacuum pans, and 68 direct and 54 dividend grainers, together with the 4 shafts, can produce 6,000,000 barrels; while Kansas, with its 4 shafts, 36 pans, and 20 grainers, is capable of producing 4,000,000 barrels. If we add to this the other salt-producing localities of the United States, it is evident that a low estimate of our present producing capacity is 20,000,000 barrels per year; hence prices of almost all grades of salt have been so low that many manufacturers, especially in Syracuse, have given up the production for the last few years, or only made small quantities to keep their works in repair, as salt works when not in use very soon become a total loss. Syracuse to-day illustrates this fact in a forcible manner, since of the 250 salt blocks in operation 15 years ago less than one half are left, and most of these are in a deplorable condition.

The demand for salt for industrial purposes is increasing slowly, but not in the proportion that was expected, since our largest enterprise in this direction, the Solvay Process Company, which makes soda-ash, caustic soda, and baking soda, must use brine.

The production of salt in the United States and the imports and exports into and from the country are given in the following tables. The statistics of production for the years 1883–90, both inclusive, are from the *Mineral Resources of the United States;* those for 1891 and 1892 were collected by the *Engineering and Mining Journal.* The output in most States is reported in bushels and barrels, while in Utah, Kansas and Nevada the product is partially rock-salt, stated in short tons, and in Louisiana is entirely so. In these cases bushels and tons have been converted to barrels for uniformity in the tables. The imports and

exports are given in pounds, and it is to be regretted that producers do not report their production uniformly in pounds or tons, instead of using such various measures as barrels, bushels, etc., as at present.

PRODUCTION OF SALT IN THE UNITED STATES BY STATES AND TERRITORIES. (*a*)

States.	1883.		1884.		1885.		1886.		1887.	
	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.
		$		$		$		$		$
Michigan	2,894.672	2,344,684	3,161,806	2,392.536	3,297,403	2,967,663	3,677,257	2,426,989	3,944,309	2,291,842
New York	1,619.486	680,638	1,788,454	705,978	2,304,787	874,258	2,431,563	1,243,721	2,353,560	936,894
Ohio	350,000	231,000	320,000	201,600	306.847	199,450	400,000	260,000	365,000	219,000
West Virginia	320,000	211.0 0	310,000	195,000	223,184	145,070	250,000	162,500	225,000	135,000
Louisiana	265,215	141,125	223.964	125,677	299,271	139,911	299,691	108,372	341,093	118,735
California	214,286	150,000	178,571	120,000	221,428	160,000	214,285	150.000	200,000	140,000
Utah	107,143	100,000	114.285	80.000	107,140	75.000	164,285	100,000	325,000	102,375
Nevada	21,429	15,000	17,857	12,500	28,593	20,000	30,000	21,000		
Kansas										
Other (*b*)	400,000	377,595	400,000	364,443	250,000	243,993	240,000	352,763	250,000	150,000
Total barrels	6,192,231	4,251,042	6,514,937	4,197,734	7,038.653	4,825.345	7,707,081	4,825,345	8,003,962	4,093,846
Total tons	866.912		912.091		985.411		1,078,991		1,120,555	

States.	1888.		1889.		1890.		1891.		1892.	
	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.	Barrels. (*c*)	Value.
		$		$		$		$		$
Michigan	3,866,228	2.261.743	3,856,929	2,088,909	3,837.632	2,302,579	3,927,671	2,136.653	3,812,054	1,906,027
New York	2,318,483	1,130,409	2,273,007	1,136,503	2,532.036	1,266,018	3.532,600	1,942.930	4,400,000	2.200,000
Ohio	380,000	247,000	250,000	162.500	231,303	136.617	397.000	264,000	460.000	276,000
West Virginia	220,000	143,000	200,000	130,000	229,938	134.688	275,000	192,500	278,000	166,800
Louisiana	394,385	134,652	325.629	152,000	273,553	132,000	221,430	93,000	192,850	81,000
California	220,000	92,400	150.000	63.000	62,363	57,085	200,000	100.000	250,000	125,000
Utah	151,785	32,000	200,000	60,000	427,500	126,100	465,000	150,000	700,000	295,000
Nevada							15,000	10,000	10,000	6,000
Kansas	155,000	189,000	450.000	202,500	882,666	397,199	1,000,000	650.000	1,232,850	698,395
Other (*b*)	350,000	143,999	300,000	200,000	300,000	200,000	200,000	100,000	250,000	125,000
Total barrels	8,055,881	4,374,203	8,005,565	4,195,412	8,776,991	4,752,286	10,233,701	5,639,083	11,585,754	5,879,222
Total tons (*d*)	1,127,823		1.120,779		1.228,779		1,432,718		1,622,006	

(*a*) The figures from 1883 to 1890, both years inclusive, are from *Mineral Resources of the United States*, 1889 and 1890. The figures for 1891 and 1892 are compiled from returns from all the producers, except those in Texas, Kentucky, etc., included in "Other States," whose small output is estimated.

(*b*) Estimated.

(*c*) Barrels of 280 pounds

(*d*) Short tons—2000 pounds.

IMPORTS AND EXPORTS.

Years.	Imports.		Exports.		
	Pounds.	Dollars.	Pounds.	Dollars.	
1867	483.775,185	1,032,871	33,926,760	304,030	Fiscal years ending June 30.
1868	528,421,176	1,281,003	35,098,320	289.936	
1869	544,147,990	1,246,439	24,805,932	190,076	
1870	638,255,726	1,305,067	16,695,952	119,582	
1871	558,724.372	1,115,772	6,728.736	47.115	
1872	515,870.037	1,101,462	2,385,765	19.978	
1873	727.506.249	1,780,401	4,106,088	43,777	
1874	785.669,705	2,101.997	1,772.792	14,701	
1875	719,943,406	1,749,651	2,637.264	16,273	
1876	710.744,358	1,615.584	2,856,784	18.378	
1877	803.050.112	1,592.771	3,683.176	20,133	
1878	766.923,489	1,546,903	4.055,912	24,968	
1879	810.046.604	1,682,723	2,649,760	13,612	
1880	850,714,403	1,728,507	1,242.024	6,613	
1881	941,803.333	1.900,609	2,545,400	14,752	
1882	729.069.538	1,561,131	2,356,760	18,265	
1883	1,447.406,276	2,635,273	4.188,317	27,072	Up to Dec. 31, calendar years.
1884	878.816.823	1,520.685	3,987,008	26,935	
1885	880,579,875	1,576,753	4,216,174	27,326	
1886	792,437,314	1,450,634	4,828,863	29,580	
1887	712,444,544	1,267,111	4,685,080	27,177	
1888	663.530,095	1,030,198	5,359,235	32,986	
1889	503,629,902	944,213	5,378,450	31,405	
1890	527,835,772	932,905	4,927,022	30,079	
1891	463,455,263	793,115	5,242,280	29,510	
1892	456,603.133	768,734	5,457,558	31,648	

NATURAL SODA.

By Thomas M. Chatard, Ph.D.

Natural Soda is the residue obtained by the evaporation of natural alkaline waters without the aid of artificial heat. It is composed of sodium carbonate and bicarbonate in varying proportions, mixed with impurities, mainly sodium chloride and sulphate. It is found to some extent in all dry regions, such as Hungary, Egypt, and the deserts of Africa and Asia; but Nature has been especially bountiful to the United States in giving us a most valuable source of national wealth in the despised and detested "alkali dust" and "alkali water" of the Great Basin.

In its crude condition natural soda has been collected and utilized from the earliest times, but until its nature had been studied and proper purification methods devised the alkaline carbonates contained in it could not be obtained sufficiently pure and cheap to compete with the artificial product. Now that the technology of natural soda is fairly well understood we may expect that the attention of capital will be drawn to the possibilities of this industry, the slender beginnings of which may be seen at a few places in the West.

Bulletin No. 60 of the United States Geological Survey contains a paper by me on "Natural Soda: Its Occurrence and Utilization." In that will be found information about foreign and American localities so far as then obtainable, and also the results of investigations by myself and others undertaken from a technical standpoint.

Every one has seen or heard of the "alkali deserts" of the West, and the sight of plains covered with a snow-like mantle of salts is familiar to every transcontinental traveler. These salts are mainly sodium carbonate, sulphate, and chloride, sulphate predominating on the eastern side of the basin, carbonate on the western side, chloride, as in the Great Salt Lake, occupying a central position. Of course this division is only approximate, and the salts are generally mixtures of all three. The incrustations are rarely of sufficient thickness and extent to become valuable in the near future, particularly as the "sinks," or lakes without outlet, in which Nature has collected and concentrated the leachings and drainage of the alkaline districts, already contain more sodium carbonate than

would suffice to supply the entire world-demand for generations. That this is no exaggeration is made evident by considering only three of these lakes.

In southeastern Oregon is Albert Lake, area 40 square miles, average depth 10 ft.; in Mono County, California, we find Mono Lake, area 85 square miles, average depth 60 ft.; in Inyo County, California, lies Owens Lake, with an area of not less than 100 square miles and an average depth of over 17 ft.

My analyses of the water of these lakes give the following results stated in grams to the liter:

	Albert Lake.	Mono Lake.	Owens Lake.
SiO_2	.232	.0700	.220
K	.538	.9614	1.644
Na	14.690	19.6853	28.500
Ca	——	.0200	.014
Mg	——	.0551	.005
Fe_2O_3	——	.0030 (with Al_2O_3)	.014
Al_2O_3	——		.024

	Albert Lake.	Mono Lake.	Owens Lake.
SO_4	.706	6.6720	7.505
CO_3	9.486	13.6903	19.398
B_4O_7	——	.1600	.367
Cl	13.462	12.1036	19.344
H (in $NaHCO_3$)	.058	.0522	.063
	39.172	53.4729	77.098

If we unite these constituents into the combinations in which, for all practical purposes, they exist in the water, we shall get these figures:

		Albert.	Mono.	Owens.
Silica	SiO_2	.232	.0700	.220
Iron and alumina	$Al_2Fe_2O_3$	——	.0030	.038
Calcium carbonate	$CaCO_3$	——	.0500	.055 (with $MgCO_3$)
Magnesium carbonate	$MgCO_3$	——	.1928	
Sodium borate	$Na_4B_4O_7$	——	.2071	.475
Potassium chloride	KCl.	1.027	1.8365	3.137
Sodium chloride	NaCl	21.380	18.5033	29.415
Sodium sulphate	Na_2SO_4	1.050	9.8690	11.080
Sodium carbonate	Na_2CO_3	10.611	18.3556	26.963
Sodium bicarbonate	$NaHCO_3$	4.872	4.3856	5.715
		39.172	53.4729	77.098

If we take the cubic foot = 28.32 liters, the pound = 453.6 grams, the acre-foot = 43,560 cubic ft., and the areas and depths already given, we shall get for the amount of sodium carbonate and bicarbonate in these three lakes alone the following surprising figures:

	Acre-feet.	Na_2CO_3 Tons.	$NaHCO_3$ Tons.
Albert Lake	256,000	3,428,352	1,560,000
Mono Lake	3,264,000	75,072,000	17,936,000
Owens Lake	1,088,000	39,875,200	8,431,000
		118,375,552	27,927,000

It must be remembered that we have considered but three localities. They are the largest, but there are many others, aggregating probably a far greater amount. Summer Lake, 25 miles north of Albert Lake, is equally large and is considered to have the same composition, while the country between these lakes and Owens Lake is very alkaline and shows many smaller ponds. Of these the best known are the two lakes at Ragtown, Nev., from which alkaline carbonates have been extracted for many years, as is also the case in Long Valley, Cal. The works at Owens Lake will be noticed later. Many of these smaller occurrences are much nearer existing main lines of transportation than any of the larger ones, and if worked can be made valuable feeders to centrally located refining works. The

refining cost at such works must always be much less that at those situated on the shores of the large lakes. It should cost no more to produce the crude material at the small places than at the larger ones, and may cost even less. The difference to be considered is the increased cost of transportation to the refinery, and it will be found that well-situated central works can afford to pay this and still compete with those at the source of supply.

Extraction of the Carbonates.—The foregoing analyses are fairly representative of all the alkali localities on the western side of the Great Basin. All contain sodium carbonate and bicarbonate, and it is upon their property to form a compound more soluble than the bicarbonate but less so than the carbonate that the method of extraction is founded. If we have a solution of the two salts, with or without sulphate or chloride, and expose it to spontaneous evaporation, we shall, at a certain degree of concentration, get a crop of acicular crystals which have the following composition:

Soda,	Na_2O,	41.15%	or	Sodium carbonate,	Na_2CO_3,	46.90%
Carbonic acid,	CO_2,	38.94%	"	Sodium bicarbonate,	$NaHCO_3$,	37.17%
Water,	H_2O,	19.91%	"	Water,	H_2O,	15.93%

From this we derive the formula $Na_2CO_3 + NaHCO_3 + 2H_2O$, which has long been known under the mineral name of urao, but we shall call it "summer soda," its name at Ragtown, and one descriptive of its mode of formation.

The amount of this salt thus obtained will depend upon the proportion of bicarbonate present, as every 37.17 parts will in crystallizing take with it 46.9 parts of Na_2CO_3. If more than sufficient bicarbonate was originally present, the excess will crystallize out before any "summer soda" forms. If too little is present, the excess of carbonate remains in solution.

Now if we evaporate a sample of water from any of the described lakes it will be seen that at a certain concentration point (sp. gr. 1.260 for Owens Lake water) crystallization will begin. The crystals are crude summer soda. Owing to the presence of so much sulphate and chloride in the solution the crop becomes more and more contaminated with these salts as the concentration proceeds. Hence to obtain an article of a fair degree of purity the process must be interrupted at some definite degree of specific gravity and the mother liquor be drawn off. If the mother liquor be further evaporated successive crops can be obtained, the earlier ones, in the case of Owens Lake, being principally sulphate, and the later ones chloride; while finally we get a mother liquor rich in potash salts, from which, on cooling to a low temperature, the ordinary "soda crystal" ($Na_2CO_3 + 10H_2O$) is deposited.

Now while all of these localities can produce summer soda in the manner described, none have enough bicarbonate in their waters to give the largest possible yield. It is necessary to increase the proportion of bicarbonate, which can be done in several ways, but most economically, perhaps, by utilizing the carbonic acid given off in the process of furnacing the summer soda. This when heated to a moderate degree loses its water and excess of carbonic acid, 100 parts yielding 70.35 parts "ash," 9.74 parts gas, and 19.91 parts water. This furnacing must be done in any event to reduce weight and save transportation charges; hence, if the gas can be economically used, there is a clear gain. The space

allotted for this paper does not permit the giving of details of investigations, but it can be said that there are no great technical difficulties in the way.

Information that I have received lately is to the effect that at present all the product is shipped in its crude condition to borax-works in the vicinity, where it meets with a ready sale at very remunerative prices. The present annual output is given as some 2500 tons, while the Ragtown works produce about 800 tons. Figures of cost now obtainable are sufficiently low to warrant the assertion that there are several places at which ash of very satisfactory quality can be made at a cost not exceeding five dollars per ton.

Manufacturing Plant.—The manufacture of high-grade soda-ash and other products from the natural material divides itself into two stages, each perfectly distinct from the other.

1. Field work, including vat construction and arrangement, pumping and handling of the original solutions and the mother liquors, control of the crystallization process, gathering of the summer soda, and transportation of it to the refinery.

2. Refining work, in which the summer soda is put into various marketable forms and delivered to the consumer.

The field work is peculiarly dependent for its conduct and economy on the climatic conditions. These, while most favorable for evaporation and crystallization, produce a scarcity and consequent high cost of manual labor. The amount of this must therefore be reduced to a minimum and be supplemented by machinery. The use of the latter, when driven by steam, is limited, however, by the fuel cost, which will always be high. Windmills can be used for pumping, and simplicity of arrangement and various mechanical devices can greatly increase the efficiency of the workmen, particularly in gathering the crop. If in a large plant the vats are properly arranged, accurate control will be made easier and the transportation cost reduced to a minimum by the use of light railways.

The field work can be done on a large or a small scale with probably equal advantage. At the Little Lake at Ragtown in 1886 two men made 300 tons and could have done much more had the conditions of the locality permitted it. The product of the Big Lake, made under very adverse conditions, required but little more labor in proportion. The entire product is hauled 16 miles to the railroad and shipped to San Francisco, where it is refined.

This example shows that in the development of this industry the innumerable small localities can be utilized quite as well as the larger ones if transportation to the refining point be not too expensive. An intelligent, industrious man, working a small but well situated pool, can produce, with only occasional outside aid, an amount of summer soda which a refining works can take at a price advantageous to itself and very remunerative to him. Furnacing before shipping to the refinery is not always advantageous. True, the reduction in weight is about 25%, but the saving in transportation will rarely pay for the cost of furnacing when this is done on a small scale. Moreover, refiners will prefer unfurnaced material, and by devoting attention exclusively to the production of summer soda, regularity in composition, which is very important, can be better assured. The field work can therefore be made "a poor man's job," a thing much needed in that region, and in time there will be a large direct consumption of the crude material.

On the other hand, the refining work, from its nature, can hardly be economically done on a small scale. It will require thoroughly trained workmen and an almost automatic arrangement of the most improved machinery. The designing and erection of such works are not simple matters, for there is little precedent for our guidance. The forms of machinery and furnaces used in the Leblanc and ammonia-soda processes are not suitable for this industry, though the principles can be applied with substantial modifications in design. The furnace temperatures are low, and thus fuel is saved; but careful management is necessary, and the furnaces must be continuous and nearly automatic. The utilization of the furnace gas and the economical handling, packing, shipping, transporting, and marketing of the products present many interesting problems which may have to be solved by novel devices and arrangements. In general the distance to the ultimate market will be great and every saving will be necessary.

The question of the utilization of the mother liquors is not at present of importance, and may be left untouched until through the development of manufacture the need of disposing of the waste products makes itself felt.

It would seem that the time must soon come when these vast natural resources will attract the serious attention of capital and business enterprise. The path is open. The general chemical lines are already well known, and the engineering problems, while numerous, are neither very complex nor very difficult. With the present steady development of the transportation facilities of the far West, it may reasonably be expected that these arid regions will soon become the seat of a new, great, and prosperous industry.

SULPHUR.

By William H. Adams, M.E.

The most important deposits of brimstone in the United States are found in Utah, at Cove Creek, 22 miles from Beaver, near the line of Millard County; while there are other deposits in the same Territory, at a point about 12 miles southwest from Frisco.

The first discoveries in the Cove Creek district were made in the year 1869; others in the years 1872, 1875, and 1883. This last year saw the first successful plant in operation for extraction of sulphur from the ores. Black Rock station, on the Utah Central Railroad, is the nearest shipping point, being 20 miles distant, over desert and lava-beds. The elevation of the country is 6000 feet above sea-level, with mountains to the eastward 2000 ft., and more, higher.

Shipments of sulphur from this district have been governed by existing local conditions which preclude the consumption of over 2000 tons annually. This will, however, gradually expand into a trade of generous proportions as the country develops and transportation facilities are extended.

The Dickert & Meyers Sulphur Company, which owns the works at Cove Creek, has had about 40 men employed during the past year. The mines are said to be in excellent condition for continuous production. A system of storage reservoirs, holding 2,000,000 gallons of water, has been put in, and 6-inch pipe laid about one mile, with a fall of 1000 feet to carry the water to the sulphur beds to use in hydraulicking the surface earth away. This will greatly reduce the cost of mining, since there is a large lot of earth overlying the sulphur, which in the past had to be dug and carted away.

In Nevada the Rabbit-hole Springs mines have been worked irregularly since 1880; but the excessive cost of production, transportation, etc., has brought the actual cost at consuming points so near the sale prices of imported sulphur as to limit mining to small amounts.

Large deposits of sulphur are known to exist in Wyoming, California, and Arizona, but none of them at the present time is available for working at a profit.

I estimate the sulphur consumed in the United States during 1892 as follows:

From	100,721 tons	imported brimstone 98%	98,707
"	1,825 "	domestic " 98%	1,787
"	210,000 "	imported pyrites, 43%	90,300
"	119,000 "	domestic pyrites, 44%	52,360
		Total tons sulphur	243,154

As the larger part of the brimstone noted in the following tables comes from Sicily, it is interesting to know something of that famous island in the Mediterranean Sea and of its deposits, which have been worked more or less during the past 300 years.

PRODUCTION OF BRIMSTONE AND PYRITES IN THE UNITED STATES.

Year.	Brimstone.		Pyrites.		Total Value.
	Amount, Short Tons.	Value.	Amount, Short Tons.	Value.	
1882	600	$21,000	13,440	$72,000	$93,000
1883	1,000	27,000	28,000	137,500	164,500
1884	500	12,000	39,200	175,000	189,000
1885	715	17,875	54,880	220,500	238,375
1886	2,500	75,000	61,600	220,000	295,000
1887	3,000	100,000	58,240	210,000	310,000
1888	.....	....	60,850	167,658	167,658
1889	450	7,850	104,950	202,119	209,969
1890	.....	......	126,039	273,745	273,745
1891	1,200	39,600	122,438	317,280	353,280
1892	1825	54,750	119,000	357,000	411,750

IMPORTS OF SULPHUR INTO THE UNITED STATES FROM 1867.

Years.*	Crude.		Flowers of Sulphur.		Refined.		Total Value.
	Quantity, Long Tons.	Value.	Quantity, Long Tons.	Value.	Quantity, Long Tons.	Value.	
1867	24,544.10	$620,373	110.05	$5,509	250.55	$10,915	$636,797
1868	18,150.55	446,547	16.48	9,948	64.75	12,721	450,216
1869	23,589.69	678,642	96.59	4,576	645.04	27,149	710,367
1870	27,379.60	829,677	76.34	3,927	157.24	6,528	831,132
1871	36,131.46	1,213,202	65.54	3,514	92.26	4,328	1,221,044
1872	25,379.55	764,798	35.97	1,822	56.94	2,492	769,112
1873	45,533.27	1,301,000	55.29	2,924	35.97	1,497	1,305,421
1874	40,989.55	1,260,491	51.08	2,694	56.68	2,403	1,265,588
1875	39,683.10	1,259,472	17.83	891	.....	....	1,260,363
1876	46,434.72	1,475,250	41.07	2,114	43.87	1,927	1,479,291
1877	42,962.69	1,242,888	116.34	5,873	1,170.80	36,962	1,285,723
1878	48,102.46	1,179,769	158.71	7,628	149.51	5,935	1,193,332
1879	70,370.28	1,575,533	137.60	6,509	68.94	2,392	1,584,434
1880	87,837.25	2,024,121	123.70	5,516	158.36	5,262	2,034,899
1881	105,096.54	2,713,485	97.66	4,226	70.96	2,555	2,720,266
1882	97,504.15	2,627,402	158.91	6,926	58.58	2,196	2,636,524
1883	94,539.75	2,288,946	79.13	3,262	115 33	8,487	3,296,695
1884	105,112.19	2,242,697	178.00	7,869	126.00	4,765	2,255,331
1885	96,839.44	1,941,943	120.56	5,351	114.08	4,060	1,951,354
1886	117,538.35	2,237,989	212.61	8,739	116.05	3,877	2,250,605
1887	96,881.55	1,688,360	278.56	9,980	83.55	2,383	1,700,723
1888	120,104.00	1,927,336	60.00	1,921	......	3	1,929,260
1889	135,935.00	2,068,208	282.00	8,184	10.00	299	2,076,691
1890	131,096.00	2,147,481	†181.02	†5,139	†10.33	†299	2,152,919
1891	116,971.00	2,675,192	....	....	....	....	2,675,192
1892	100,721.00	2,189,307	....	....	....	....	2,189,307

* Fiscal years ending June 30 from 1867 to 1887, inclusive; subsequently, calendar years ending Dec. 31, unless otherwise specified. † Fiscal years.

TABLE SHOWING THE CONSUMPTION OF SULPHUR IN THE VARIOUS COUNTRIES OF THE WORLD—AN AVERAGE PER ANNUM FOR THE PAST FIVE YEARS. TONS OF 2000 LBS.

Countries.	Brimstone.	Sulphur in Pyrites.	Totals.
England	47,500	210,000	257,500
America (United States and Canada)	125,000	102,080	227,080
France	56,000	78,000	134,000
Germany	17,600	84,000	101,600
Italy	46,500	10,000	56,500
Belgium	18,500	33,500	52,000
Russia	26,600	....	26,600
Austria	9,300	16,000	25,300
Spain	3,200	7,500	10,700
Holland	2,900	7,600	10,500
Norway and Sweden	6,700	4,500	11,200
Australia	2,430	....	2,430
Greece and Turkey	730	....	730
Portugal	550	....	550
Other countries	1,200	....	1,200
Totals	364,710	553,180	917,890

From late Government statistics we learn that the estimated quantity of sulphur in the accessible mining districts, before workings were begun, was 65,000,000 tons. No regular reports were kept of the early sales, but it is fair to estimate that at least 2,000,000 tons were sold up to the year 1831. From 1831 to 1885

nearly 8,400,000 tons were marketed, and from 1885 to the close of 1892 about 2,400,000 tons have been reported—a grand total of about 12,800,000 tons of sulphur. The values of this tonnage may be safely estimated at $350,000,000, all of which has been won from mine ores averaging less than 20% of sulphur, therefore representing over 60,000,000 tons of mine materials handled in some manner. These aggregate figures of a single mine product, from a single locality, are presented to show how very favorably situated are the deposits, and how exclusive has been the trade in this essential chemical base until a very recent date.

The sulphur found on this island is of two kinds, one of which is closely allied to sedimentary rocks, and the other is from volcanic emanations. There is a general belief that Mount Etna, in the eastern part of Sicily, is responsible for these deposits; but scientists do not at present accept this theory, offering several explanations to account for the varying conditions which extensive workings have disclosed. Thus: (*a*) emanations of sulphur vapor expelled from metallic matter existing in the earth, (*b*) sulphuretted hydrogen (from the union of sulphur vapor and steam) passing through fissures of stratified rocks, (*c*) sulphuretted hydrogen from the decomposition of calcium sulphate in the presence of organic matter, (*d*) the action of sea-water upon animal remains, etc. Any of these explanations can be abundantly exemplified, and many specimens of interest in connection with the deposits as worked from year to year can be found at the Government school in the neighborhood of Caltanisetta, such as specimens of fish, eggs, insects, etc., embedded in the marls, bitumen, rock-salt, and other strata which underlie the sulphur. About 250 mines are now working, but the number is diminishing gradually as the necessity arises for more extended operations and increased outlays. As in nearly every industry of this special character, the tendency of late is to concentrate the ownership of the best mines in strong hands, and to regulate prices according to demands for sulphur—as witness the fluctuations during the past few years.

The cost price of brimstone has varied but little for several years, and the following figures, compiled from late Government returns, will show detailed expenditures in connection with the business:

COST OF BRIMSTONE AT SHIPPING PORTS IN SICILY.

Mine Cost (average) per Metric Ton.	Lire.	Lire.
Labor	30.992	
Management	1.162	
Supplies	1.080	
Fuel	1.841	
Exploration and preparatory work	1.393	
Machinery account	0.445	
Interest on floating indebtedness	1.534	
Local taxes and other expenses	3.093	
		41.54
All costs of melting		8.00
Government and town dues (average)	20.00	
Railway freights to coast cities	14.00	
Cartage from railway to storehouse	0.80	
Lighterage to vessels	2.10	
Customs charges (average)	12.00	
Chamber of Commerce dues	0.25	
Commission on sale	0.35	
		49.50
Total cost per metric ton of brimstone		98.04
Or, 98.04 × 19.3 (cents in a lire) = $18.92 per metric ton, or, per ton of 2000 pounds, free on board vessels in Sicily, is		$16.00
Add average freights to points of consumption, say		4.00
Total cost price of one ton brimstone delivered at Atlantic ports		$20.00

The Market for Brimstone.

The course of the brimstone market during 1892 has been a steady decline. In January the spot price was $33 per ton for best unmixed seconds; in December the price for the same article under the same conditions was $10 lower. The year closes with the following quotations: Best unmixed seconds, ex steamer due, $24; shipments, $20.50@$21; thirds, $1 less.

The imports, as may be seen from the table elsewhere printed, have been smaller for 1892 than for the preceding year. The increase in the use of pyrites for acid-making has seen a corresponding decrease in the consumption of brimstone. Again, last year many fertilizer factories carried over large manufactured stocks, owing to the depression in the fertilizer market, and in 1892 their consumption of brimstone fell below that of the preceding year.

To this decreased consumption, as well as to the fact that there were large stocks on hand in Europe, must be attributed the decline in the price of Sicilian sulphur. It naturally put an end to the receipts of Japan brimstone at this port. The last arrivals were in March, and they formed part of the output of Japan in 1891. The imports into this country of the Japanese article amounted to 10,525 long tons in 1892, this quantity representing a portion of the total production of Japan during 1891 and 1892. The bulk of the latter year's output was sold in Japan, China, and Australia.

HIGHEST AND LOWEST PRICES OF BRIMSTONE, ON THE SPOT, DURING 1892.

	January.		February.		March.		April.		May.		June.	
	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.
Best unmixed seconds....	$33.00	$28.50	$29.00	$26.00	$25.00	$24.00	$25.00	$23.00	$24.00	$23.00	$24.00	$23.00
Best unmixed thirds....	32.00	27.50	28.00	25.00	24.00	23.00	24.00	22.00	23.00	22.00	23.00	22.00

	July.		August.		September.		October.		November.		December.		Average.
	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.	
Best unmixed seconds..	$25.00	$24.00	$25.00	$24.00	$24.50	$24.00	$24.00	$23.00	$25.00	$24.00	$0.620	$23.00	$24.95
Best unmixed thirds....	24.00	23.00	24.00	20.00	23.50	23.00	23.00	22.00	24.00	23.00	25.00	22.00	:3.95

It must be borne in mind that the prices given in the above table are for brimstone "on the spot," ready for immediate delivery at the time of sale. Future shipments, delivery to be made from one to three months after the time of sale, have ruled from $2 to $6 lower. The supply of brimstone on the spot is always limited, and the buyer who has urgent need of the article is forced to pay the higher price.

Pyrites.

The production of pyrites in the United States for the year 1892 has been confined to the States of Virginia and Massachusetts, although a small tonnage has been raised in experimental workings in North Carolina and Wisconsin.

The mines of Louisa County, Virginia, have continued to develop their several deposits during the year to a greater extent than ever before, the increased trade of the Southern States warranting a constantly increasing output.

The Sulphur Mines Company this season has added many features to its property, including a complete crushing, sorting, grading, and washing plant, stated to have a daily capacity of 300 tons, and has pushed developments underground to an extent which warrants an output of 100,000 tons of pyrites next year.

This mine is now opened for nearly a mile in length on the veins, which vary in width of lenticular deposits from 15 to 80 ft., and nearly 2000 ft. of length is now being worked through several shafts. This year's shipments amount to about 45,000 tons, with a constantly increasing demand.

The Arminius mines, two miles southeast from the sulphur mines, and two miles from Mineral City station on the Chesapeake and Ohio Railway, have continued the shipments of ore at about the same rate as for several years past,—about 80 tons daily for the year,—and have further developed their property in depth by sinking the main shaft to nearly the 600 level. Below the 400 level the mine is substantially dry, in this respect like all the deep pyrites mines of the Old World.

This mine is fully equipped with a plant consisting of crushing, grading, and concentrating machinery sufficient for an output of 50,000 tons annually, and the reserves of the mine, above the 550 level, have been kept at over 500,000 tons.

One newly developed deposit on this belt is to be credited to this year, viz., the property of the Virginia Pyrites Company, which adjoins the lands of the Sulphur Mines Company on the north.

An incline shaft has been sunk in the hanging slates to a depth of 160 ft., and the vein disclosed by means of two cross-cuts from this shaft. No large amount of ore has yet been shipped, nor a great extent of vein matter opened up, but extensive buildings are being erected to handle the trade of another year.

Several development openings have been made along the belt in both directions from the Mineral City center, in Louisa County, but with no special results to chronicle.

During the year 1891–92 an opening on ore was made within six miles of Meadows Station on the Richmond, Fredericksburg and Potomac Railroad, near Quantico. A few hundred tons of excellent pyrites have been mined and shipped to Baltimore by way of the Potomac River, and work is still going on, with every prospect of success in further developments.

It is astonishing that capital is not attracted to the possibilities of this class of mining along the mineral belt from Maryland to the Georgia line. No large amount of money is required to locate deposits of pyrites which are valuable for their gold and copper contents, and there is an unlimited demand for the products which these ores invariably carry. Success has been won from the unpromising

fields in the Carolinas, worked for years without much profit until the improved and simplified process in chlorination of concentrates was demonstrated by Adolph Thies, at the Haile mine, Lancaster County, South Carolina, and this is but the beginning of an era of mining on strictly legitimate lines which will redound vastly to the resources of the Appalachian belt in the years to come. With the proper metallurgical plant established at some central point for the shipment of gold-bearing ores, and for the manufacture of acids, copper, fertilizers, etc., an industrial center could be built up second to none on this continent—one well worthy the attention of capitalists, and an example comparable only to Old World plants.

The Davis mine, in Franklin County, Massachusetts, continues to be the only producing mine in that State. The shipments for the present year will be 40,000 tons.

The following table gives the imports of pyrites into our country, commencing with the year 1881, when Canadian ores for the second time were brought into New York for use of the contained sulphur and copper:

IMPORTS OF PYRITES INTO THE UNITED STATES SINCE 1881.

Year.	Quantity, Long Tons.	Average Sulphur Contents, Per Cent.	Year.	Quantity, Long Tons.	Average Sulphur Contents, Per Cent.
1881	11,927	35	1887	60,000	38
1882	29.818	35	1888	81,000	42
1883	35,811	36	1889	100,000	43
1884	44,250	36	1890	115,000	43
1885	50.000	38	1891	130.000	44
1886	60.000	38	1892	210,000	43

The growth of the trade in pyrites in America, by districts, is shown by this table:

CONSUMPTION OF PYRITES IN THE UNITED STATES.

	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
New York and vicinity...	7,000	23,900	29,500	39,000	44 600	55,700	59,000	64,000	72,000	80,000	100,000	90,000
Boston and East'n States	.....	2,500	7,500	14,500	25,800	26,900	27,000	30,000	35,000	40,000	45,000	47,000
Philadelphia and vicinity	.....	2,500	5,000	5,500	11,500	23,600	25,000	25,000	28,000	32,000	50,000	55,000
Baltimore and vicinity. .	.....	.....	2,000	4,000	7,500	4,300	5,500	7,000	12,500	14,000	14,000	20,000
Southern States..........	1,000	2,000	3.000	3.000	3,000	3,000	3,500	4,500	7,000	16,000	26,000	30,000
Western States...........	.....	.....	1,000	2,000	4,000	5,000	5,000	10,500	30,000	40,000	55,000	75,000
Totals...	8.000	29,900	48,000	68,000	96,400	118,500	125,000	141,000	184,500	22,5000	290,000	317,000

There is much of interest to be found in these tables—much that at first glance does not appear, yet which is worthy of careful study.

Thus the highly significant fact is noted that the rapid growth of industries which are large consumers of sulphuric acid, and really dependent upon its use for their successful operations, is due almost wholly to the discovery in this country of two original mine-products—petroleum and rock-phosphates. Over 40,000,000 barrels of crude petroleum are added to our annual products, of which amount nearly one half is exported in some shape. It takes one pound of sulphuric acid (66° Baumé) to produce a gallon of commercial petroleum (kerosene), from which statement the enormous values belonging to this original trade alone can be estimated.

Over 400,000 tons of phosphate rock are mined and consumed in this country

each year. It requires a ton of chamber-strength sulphuric acid to decompose or dissolve a ton of rock in the manufacture of acid-phosphate or fertilizers, from which statement the values of this mine trade can be estimated.

In this connection an anomalous condition has existed up to within a recent date, i.e., hundreds of thousands of tons of phosphatic materials have been manufactured into fertilizers at plants along the coast-line of the Northern States, requiring all the surplus acid of the older works and necessitating the erection of new works for this special purpose. Nearly the entire tonnage of phosphatic material for this use was mined and freighted from the Southern States, and the bulk of the goods so manufactured was returned to the South to be sold.

This trade is gradually changing to legitimate lines, and within a few years sufficient acid will be manufactured in the South to meet all requirements, not only saving a percentage of the freights from points of production to points of consumption, but lessening the cost of raw materials by the utilization of other products found within her own borders.

The demands for sulphur products, after petroleum and phosphates have consumed the greater part of the stocks, are: (*a*) for manufacture of mixed acids, to be used in preparation of explosives, such as nitro-glycerine, cellulose, etc.; (*b*) for bleaching-paper pulp, etc.; (*c*) for manufacture of hydrochloric, nitric, and nitrous acids, used in general manufacturing; (*d*) for carbonating soda and mineral waters; (*e*) for other chemical uses.

During the year 1892 three works in Atlanta, Ga., one in Charleston, S. C., one in Richmond, Va., and three in Baltimore, Md., changed from brimstone to pyrites, and one new works was erected in Richmond, Va., to burn ores. In the Northern States three works were changed to use ores in combination with brimstone.

The best practice of the world is based upon getting sulphur from pyrites at just about half the price of brimstone, which may be stated in another way thus:

One ton of brimstone "seconds" has cost during the year 1892, the average ex-ship at the Atlantic ports....	$25 00
This ton of brimstone will net, after allowing for all losses, such as handling, storage, waste gas, etc., 95 units of pure sulphur.	
The equivalent of above 95 units of sulphur can be purchased in 2½ tons of pyrites and laid down at any of the Atlantic coast factories for....	12 50
The difference is the saving which can be made in the first cost of 95 units of sulphur from pyrites.....	$12 50

In a large way, and under expert management, the cost of utilizing sulphur from ores does not exceed the cost of burning brimstone; therefore it is demonstrable that for the past twelve years the saving to consumers who have pyrites plants has been at the rate of $10 per ton of sulphur used. This statement is made with a full knowledge of its import, and based upon a practical experience with pyrites from a date when the first large demonstrations were made to utilize them. Corroborative of this, a working example is cited:

SULPHURIC ACID MADE FROM SULPHUR.

144,000 lbs. brimstone "seconds" delivered at works, $25 per ton....	$1800.00	Coal, 45,000 lbs....	56.25
5040 lbs. nitrate soda....	104.83	Insurance, wear and tear, etc....	214.10
Labor account for 30 days, 4 men....	195.00	Management at works....	72.00
		Total cost....	$2442.18

Production was 354.6 tons of 50° Baumé sulphuric acid, or, cost per ton for chamber acid, $7.066.

SULPHURIC ACID MADE FROM PYRITES.

55.8 tons pyrites, containing 43% sulphur, delivered, at $7.50	$418.50
3184 lbs. nitrate soda	45.36
Labor account	91.00
Coal account	26.00
Insurance, wear and tear, etc.	92.50
Management at works	31.20
Total cost	$703.56

Production was 141 ton of 50° Baumé sulphuric acid, or, cost per ton of chamber acid, $5.

More concisely stated, to emphasize the point intended to be made:

The sulphur in one ton of chamber acid, as per the above example, *from sulphur*, costs	$5.20	
The manufacturing and other costs are	1.86	
		$7.06
The sulphur in one ton of chamber acid, as per the above example, *from pyrites*, costs	$2.97	
The manufacturing and other costs are	2.03	
		$5.00

It is unnecessary to repeat examples, or to answer statements which differ in results only as they are governed by local conditions—the entire value to the large manufacturer being the cost of the raw materials which he consumes; but aside from the facts which insure acids at a less cost when manufactured from pyrites, there is yet the strongest reason why pyrites, a product so generally distributed over the earth's surface, should be utilized by the larger concerns in preference to brimstone, which has always been limited in supply.

It requires but a glance at the tables to recognize the importance of being at all times free from the dictation of mine-owners in Sicily, whose maximum output is about 330,000 tons yearly, and to secure to ourselves the increasing amounts of sulphur required by expanding trades, at prices which are, and always will be, so much below the cost of brimstone. If there were no more in this proposition than the mining and utilization of American pyrites for all the minerals they contain, it would seem to be the province of the manufacturers of this country to solve the well-known Old World problems at once and thus inaugurate new industries about themselves, lessening by such means the payment of millions of gold each year to foreign producers of brimstone. It is difficult to appreciate the rapidity of growth of industries in our own country depending upon sulphur as the base of their manufacture.

In the year 1865 less than 40,000 tons of sulphuric acid were manufactured in the United States. In 1870 the amount had risen to about 70,000 tons, in 1875 to nearly 100,000 tons, in 1880 to over 285,000 tons, in 1885 to nearly 400,000 tons, in 1890 to 510,000 tons, and in 1892 to nearly 580,000 tons.

This tonnage is calculated on the basis of commercial acid, 66° Baumé, which is consumed in this country in about the following ratio:

For dissolving phosphatic rocks	nearly 53%
For the refining of crude petroleum	35%
For all other purposes in trade	12%

Summing up the year's business in products which come directly from sulphur, it may be said that no better trade has ever been known in this country. The steady and gradually increasing demand upon the chemical works has drained them of all stocks month by month, at prices so remunerative as to warrant the extension of some plants and the keeping up of all chemical works to a full standard of maximum output. The increasing demands for stronger acids, used for the manufacture of dynamite, gun-cotton, cellulose, etc., has excited surprise, and for

the first time in the history of the acid trade has enabled manufacturers to market their entire stocks in the North and at no time attempt the sale of surplus acids—whether in bulk lots or as manufactured products—in the Southern States. Except for the stagnation in cotton sales for a few months, the Southern States would have been consumers of a largely increased amount of acids in fertilizers, and this trade is growing at so rapid a pace from year to year as to demand the erection of one, two, or more chemical works annually. The very rapid increase in consumption of acid phosphates in the Western States is exciting remark and will lead to the enlargement of all the Southern seaboard works in close proximity to the phosphate deposits, and to a direct trade for the railways which reach the Middle Western grain sections.

The Canadian mines at Capelton have continued to send in their ores at the rate of 30,000 tons annually, and the extraction of the sulphur and copper from the same is the basis of one of the foremost industries of the country. These mines were opened in 1863–64, and have been steady producers of an even grade of copper ores, averaging about 35% sulphur and from 4% to 5% copper, with an ounce of silver to each per cent of copper.

Newfoundland pyrites have been shipped to us in gradually increasing amounts, and find sale along the Atlantic seaboard, where storage facilities are sufficient to warrant the carrying of stocks over the winters. That section will always be handicapped by the necessity of shipping the entire season's stock in the few summer months, but the ores are excellent and satisfactory to the users.

Spanish pyrites continue to be brought to this country, and are finding a market from Boston to Savannah along the Atlantic seaboard. We are absorbing a quality of this ore which is free from copper, therefore advantageous for the inland works, and at prices lower than known for years past. Several of the heavier manufacturers have lately changed over their plants to use this class of ore, claiming that it is fully as satisfactory in burning as brimstone, at the ratio of two tons of ore to one of brimstone.

Close study is being given in Europe and on the Continent to the recovery of sulphur from waste substances—millions of tons of residues from the Leblanc soda-works having been thrown away as practically valueless, yet containing greater values per ton than the mine ores of Sicily. It is stated on good authority that over 400,000 tons of pure sulphur are annually wasted from this source alone, and a glance at our table of the world's consumption of sulphur will show how and where this waste is going on.

The only commercially successful process at present attacking this problem is that of Shaffner and Helbig, modified and bettered by Chance Brothers of England. It rests upon a cheap method of liberating sulphuretted hydrogen from a milky solution of this tank waste or soda-works residue, by means of carbon-dioxide gas (produced by the ordinary lime-kiln process), the sulphuretted hydrogen so manufactured being stored in gasometers, passed through meters with a measured quantity of air, and carried into a Claus kiln (an iron cylinder packed with broken refractory materials), where the gases are thoroughly mixed and ignited. The flames from this kiln pass into brick chambers, where most of the sulphur is formed in a molten state, and thence into other chambers until exhausted.

The manufacture of this class of almost pure sulphur is gradually spreading,

and at present there is an output of about 70,000 tons annually, the sale of which is generally to the manufacturers of fine chemicals and to the paper-makers who bleach by the new sulphite processes.

There are several processes spoken of in this connection, as the field is so large and the rewards are so generous, but none of them is sufficiently successful as yet to warrant its introduction here.

We have so much in our own country deserving the attention of the younger chemists that hints of experiments in the direction of utilizing our enormous waste heaps and our solvents which run to waste everywhere are oftentimes more valuable than studies of the industries themselves, as hints from specialists who are unable to cover all the points naturally lead to close study of the special requirements. Nothing has more surely tended to the lowering of mine products of universal necessity than the bringing together of facts and details which attract attention, insure the co-operation of chemical knowledge and capital, and bring about, after perhaps long experimenting and working, the successes we see in business everywhere. We are indebted to the bold experimenters in chemistry for a thousand articles of common use and benefit, won from bases so unpromising as the tank waste of Europe, the sludge acid of oil-refineries, the wash liquor from gas-works, and the solutions which are wastes in almost every factory in our own land.

There is a wide field and an enormous fortune awaiting the man who will solve the problem of utilization of the residues from pyrites burners—the oxides of iron which contain a small amount of sulphur, copper, zinc, lead, etc. Some few of the mine ores of this and of other countries carry too high a percentage of silica, and oftentimes the cinders from the burners are agglutinated by reason of irregular heating; but the pyrites of commerce are generally free from foreign substances, and would be especially valuable for the manufacture of steel were the above-named substances eliminated.

There are at present about 100,000 tons of this pyrites residue thrown aside by the works of America,—the tonnage increasing at a rapid rate,—a quantity so large and at localities so accessible as to invite the attention of our bright chemists. These residues will average about 55% iron, 2% sulphur, 8% silica, 1% zinc, ½% copper, and 3% alumina.

Foreign pyrites are utilized to the fullest extent—the major part for the extraction of copper, with sale of the iron oxides; the minor part by sale of the iron oxides direct to iron-smelters.

TALC.

By Axel Sahlin, M.E.

Under the common name of talc we are accustomed to include the whole range of minerals chemically defined as hydrous bi-silicates of magnesia. In this sense talc is a common mineral, found in every State and Territory of the Union, as well as throughout Canada; but it is generally impregnated with other minerals, such as magnetite, dolomite, serpentine, or epidote, rendering it valueless for technical purposes. Pure talc is recognized by its great softness and greasy feeling. It is highly refractory and generally of a somewhat flexible, tenacious character, which makes it very difficult to crush. The different talc minerals occur in such a variety of form and approach each other so closely, that it is difficult to classify or define them comprehensively.

Steatite, or soapstone, is the most common form. When pure it is a massive, amorphous mineral, generally white, light green, or gray, but sometimes blue or rose-colored. Schistose modifications are common, and gradually approach rensselaerite, or typical foliated talc, which is composed of thin scales of an almost mica-like, pearly luster, toughness, and tenacity. The color is generally a silvery white or gray. Agalite, or fibrous talc, is found only in a few localities, and nowhere else so pure and light in color as near Gouverneur, N. Y.

The following analyses give the composition of the three typical varieties described above:

	I. Steatite, Lafayette, Pa.	II. Rensselaerite, Gouverneur, N. Y.	III. Agalite, Gouverneur, N. Y.
Loss by ignition	5.96%	.....	.....
Silica	65.16	52.42%	61.28%
Alumina	0.25	.....	.....
Ferrous oxide	1.39	.....	.....
Magnesia	27.40	36.24	26.58

Analyses I. is reported by F. A. Genth in the *Geological Survey of Pennsylvania.* Analyses II. and III. were furnished by talc manufacturing firms of Gouverneur. Intimately mixed with the talc are often found nodules, veins, and horses of anhydrous silicates, such as hornblende, hexagonite, actinolite, tremolite, and others. The manner in which these minerals unvaryingly appear has given rise to the theory that the talc was deposited originally as hornblende, which gradually has become hydrated.

In many parts of the Old World steatite has for ages been used for nearthstones, cooking-pots, and other household utensils, for which its softness and refractory nature make it especially adapted. As French chalk it has long been a familiar article in every workshop. In the United States it was in the early days of the iron industry largely used in refractory furnace linings, for bridges in puddling furnaces, etc., instead of expensive imported fire-brick, and up to this day cupola and converter linings in Eastern steel works are frequently built of soapstone. Slabs of the same material are also employed to a limited extent in the building trade. In powdered form talc finds a far more extensive employment, entering largely into the composition of mineral paints as a filler, and also as a principal component in the fire-retarding paints, which during the last few years have been put on the market so successfully. In paper manufacture talc is largely supplanting the more expensive china clay as a weightener and filler. The fibrous and foliated varieties mined near Gouverneur, N. Y., have proved especially valuable for this purpose, as of the talc added to the pulp from 75% to 90% is retained in the paper, as against 30% to 35% of the china clay similarly employed. The fibrous texture of the mineral also tends to strengthen the paper, and to do away with the brittleness characteristic of paper weighted with clay. The name mineral pulp, under which this talc is known to the trade, testifies strongly to the value of this feature. For toilet powders, in soap, and as an adulterant for many white, powdery substances, talc is also utilized extensively.

The fibrous variety of talc is mined most extensively in the vicinity of Gouverneur. The first mines were opened there about fifteen years ago, and have reached a depth of more than 400 ft. The mineral recovered is principally agalite, discolored near the surface, but turning beautifully white when a depth of 30 or 40 ft. is reached. It occurs in veins, sometimes as much as 20 ft. wide, embedded in strata of granite and gneiss. About 51,000 tons, as nearly as can be learned, were mined in this district in 1892, all of which was reduced to an impalpable powder before leaving Gouverneur. After being broken in two successive crushers, the rock is either run through two sets of burr stones, a Griffin mill, or a cyclone pulverizer, and is at last finished in Alsing cylinders. For the American market it is shipped in 50-lb. paper bags, while for export it is put up in 100-lb. canvas sacks. The requirements are fibrous nature, freedom from grit, absolute fineness and uniformity of grinding, and opaque whiteness of color. Gouverneur talc is sold, free on board in New York, for about $12 @ $13 per ton of 2000 lbs.

Fibrous talc is also mined and prepared near Wiehle, Fairfax County, Va., where the mineral recovered is fully as fibrous as the best varieties of the Gouverneur article, but is slightly discolored. The deposit worked is of considerable extent, and it is expected that the color will improve as a greater depth is reached. Fibrous talc cannot be sized by screening, as the particles mat and close the screen openings. This fact explains the elaborate and expensive processes employed to effect a uniform reduction. The supply of this most valuable mineral is very limited, and its scarcity threatens to prevent the comparatively new article produced from the same from obtaining the foothold in the interested industries which its excellent qualities would otherwise justify.

The principal centers for the soapstone industry are in the neighborhood of

Easton, Pa., and Philadelphia. On the Bushkill, near the former place, a number of veins are being worked. The mineral, which is of good quality, is reduced by means of crushers and burr stones. At Lafayette, a few miles northwest of Philadelphia, soapstone quarries of considerable importance have also long been operated. The stone is trimmed into large slabs for various purposes, while the offal is disposed of to be powdered by burr stones. There are other steatite mines near Francestown, N. H., Texas, Pa., in the neighborhood of Baltimore, and in Virginia, North Carolina, and South Carolina. The article mined and prepared at Kinsey, N. C., is noticeable for purity and color, and is sold almost exclusively to the drug trade.

The entire product of the various grades of talc marketed during 1892 is estimated at about 70,000 tons, of which 51,000 tons were fibrous talc and 19,000 tons were soapstone. The production in previous years is given in the *Mineral Resources of the United States* as follows:

PRODUCTION OF TALC AND SOAPSTONE IN THE UNITED STATES.

Year.	Fibrous Talc. Tons.*	Fibrous Talc. Value.	Soapstone. Tons.*	Soapstone. Value.
1880	4,210	$54,730	8,441	$66,665
1881	5,000	60,000	7,000	75,000
1882	6,000	75,000	6,000	90,000
1883	6,000	75,000	8,000	150,000
1884	10,000	110,000	10,000	200,000
1885	10,000	110,000	10,000	200,000
1886	12,000	125,000	12,000	225,000
1887	15,000	$160,000	12,000	$225,000
1888	20,000	210,000	15,000	250,000
1889	23,746	244,170	12,715	231,708
1890	41,354	389,196	13,670	252,309
1891	53,054	493,068	16,514	243,981
1892	51,000	459,000	19,000	266,000

* Short tons (2000 lbs.).

This table illustrates the rapid growth of an industry yet in its infancy. Originally a small business was done on a very large margin of profit. Competiton, and a conspicuous absence of advertising have greatly cheapened the product thus opening new markets which, as far as the fibrous variety is concerned, will doubtless continue to expand until, if no new deposits in the meantime are discovered, the scarcity of the mineral will limit further growth.

The tendency of our times towards consolidation is making itself felt even in the talc business, and at this writing active negotiations are in progress for the formation of a Talc Trust.

The process of "talc milling," now carried to such perfection, is the result of a gradual development from the day when, fifteen years ago, an obsolete grist mill was first adapted to the purpose. A short description of a modern talc plant may here be of interest. In 1891 the American Talc Co. commenced operations at Fowler, N. Y. Their mine shaft was sunk in a 9-foot vein of talc. It has now reached a depth of about 260 feet on a slope of 35° to 45°. The vein is composed of agalite and rensselaerite in alternate layers and of fine quality. A double-tracked inclined plane elevates the broken rock to a stock-house about 250 × 80 feet located at the mouth of the mine. The adjacent power-house contains besides hoisting engine and boiler also air-compressor and pumping machinery. Electric lighting is to be introduced in the mine as well as on the surface. The carefully-cobbled rock is delivered to the crusher-house, located about 350 feet from the mine, by an inclined cable road. It is kipped directly into a 10″ × 20″ Blake crusher. It then passes through a 5″ × 20″ granulator, whence it is elevated to a revolving screen. The rejections are returned to the granulator, the screenings

pass into the capacious receiving-hoppers. Beneath these are placed two Cyclone pulverizers provided with pneumatic separating devices and together capable of grinding 3000 pounds per hour to an absolute fineness of 140 mesh or to finish a smaller quantity outright to 200 mesh. According to the requirements of customers either plan is adopted. If the pulverizers are adjusted for delivering the larger quantity, the product is delivered into trucks in charges of 1500 to 1800 pounds each, and is so conveyed to the four Alsing cylinders. These consist of ½″ steel barrels 6 feet diameter, 10 feet long, supported on heavy trunnions and revolved at a speed of 22 to 25 revolutions per minute. The cylinders are lined with porcelain brick about 2″ × 3″ × 6″ in size and especially moulded. The lining for each cylinder weighs about 3200 pounds. The bricks cost 3½ cents per pound. The cylinder is filled to about one third with 3½ tons of flint pebbles brought from Greenland. These pebbles are worth $21.00 per ton delivered. The cylinder is kept in motion for about 1¾ to 2 hours. The man-holes are then removed, gratings substituted, the cylinder revolved slowly, and the talc discharged and passed through a coarse bolting-screen which removes any pieces of lining or pebbles that may have been detached during the grinding. The talc is now ready to go to the packer. The mill of the American Talc Co. occupies a building 100 × 44 feet, three stories high, with adjacent crusher-shed, engine and boiler room. Power is supplied by a 250-horse-power Corliss engine, condensing. Steam is raised in two tubular boilers, fired with wood, of which fuel the neighborhood furnishes an abundant and cheap supply. The plant is located two miles from the line of the Talcville branch of the Rome, Watertown & Ogdensburg Railroad, from which a track undoubtedly will be laid out to the mill. The plant described is typical of the advancement made during the last decade. The newer mills now building are planned in an even more complete and substantial manner, testifying to the solid and prosperous condition of the industry.

TIN.

By William De L. Benedict, E.M.

Cornwall seems to have been the first place from which tin was obtained within historic times. In the twelfth century tin mines were worked in Bohemia and in the Meissen district, Germany. Tin is also found in Saxony, France, Sweden, Siberia, and Spain. In the East Indies it is found in large quantities on the islands of Banca, Billiton, and Sumatra, and on the Malay Peninsula. In Australia it is found principally in Victoria, New South Wales, Queensland, and Tasmania. In South America it is found in Brazil, Peru, Chile, and Bolivia. In North America it is found in Mexico, and in California, South Dakota, Wyoming, North Carolina, Virginia, Alabama, and parts of New England.

It is stated that in Cornwall tin has been taken from mines or stream-works, or both, for more than 2000 years certainly, and probably for more than 4000 years.* Of the long period previous to the end of the twelfth century, however, very little of a statistical character is known. It would appear that from 1199 to 1216 A. D. the yield in Cornwall was from 17 to 34 tons and in Devon from 64 to 128 tons of metal annually. For the first 20 years of the thirteenth century the yearly production probably exceeded 120 tons. The average of the first 20 years of the fourteenth century in Cornwall was from 380 to 400 tons, and in Devon about half this quantity, or a total in the two counties of from 570 to 600 tons per annum. From 1320 to 1339 the production of Cornwall was about 460 tons, and of Devon 140 tons, a total of 600 tons per annum. About 1374 the average production of Cornwall and Devon was about 450 tons annually. For nearly 100 years there are no further records available, but in 1441 the output of Cornwall and Devon was about 490 tons, and in 1479 about 450 tons. Then there is another break in the records until 1524, when the production of these two counties amounted to about 600 tons. From 1577 to 1607 there was an average output in Cornwall alone of about 420 tons yearly. In addition Devon produced 70 tons yearly. In 1611 Cornwall's output was increased to 450 tons, while that of Devon probably decreased to about 50 tons, making a total for both counties of 500 tons. Thus for the whole period of 1300 to 1611 the annual variations in production were comparatively slight, although Cornwall had by this time become the main

* These particulars are obtained from a paper by Mr. J. H. Collins, entitled "Seven Centuries of Tin Production in the West of England," in the *Transactions of the Mining Association and Institute of Cornwall*, vol. iii., Parts 1 and 2.

tin producer. The proportion henceforward yielded by Devon was comparatively insignificant: from 1611 to 1640 the average was about 1000 tons per annum; from 1650 to 1725, about 1400 tons. About 1742 the average production of Cornwall alone for several years is placed at 2100 tons. From 1742 to the present time the annual production of Cornwall alone has been as follows:

LONG TONS.

Years.	Tons Metal.	Average Price.			Total Value.	Years.	Tons Metal.	Average Price.			Total Value.
		£	s.	d.	£			£	s.	d.	£
1742 to 1759 inclusive	39.600	80	2	0	3,171,060	1865	9,038	96	5	0	873,659
1760 to 1769	28,437	89	1	0	2,532,315	1866	8,822	88	12	6	781,849
1770 to 1779	29,077	83	15	0	2,435,200	1867	7,296	91	17	6	670,228
1780 to 1789	29,126	85	15	0	2,497,555	1868	7,703	98	0	0	756,494
1790 to 1799	30,293	105	0	0	3,195,910	1869	9,356	121	13	6	1,138,488
1800 to 1809	21,072	117	5	0	2,470,682	1870	10,200	127	8	6	1,299,505
1810 to 1819	23,006	96	2	0	2,210,876	1871	11,320	137	10	2	1,556,557
1820 to 1829	31,975	85	10	0	2,733,862	1872	9,560	152	15	0	1,459,990
1830 to 1839	35,160	100	0	0	3,516,000	1873	9,972	133	7	0	1,329,766
1840 to 1847	51,768	99	0	0	5,125,032	1874	9,942	108	8	0	1.077,712
1848	10,179	94	0	0	956,544	1875	9,614	90	2	0	866,266
1849	10,000	96	5	0	962.500	1876	8.500	79	10	2	675,750
1850	10,383	97	0	0	1,007,151	1877	9,500	73	3	6	695,162
1851	10,000	100	0	0	1,000,000	1878	10,106	65	12	3	663,080
1852	9.674	104	5	0	1,008,514	1879	9,532	72	6	0	689.163
1853	9,000	108	0	0	972.000	1880	8.918	91	5	0	813,767
1854	8,477	114	0	0	962,856	1881	8,615	97	9	3	839,680
1855	8,000	115	0	0	920,000	1882	9,320	106	14	0	994,440
1856	7,500	116	0	0	870,000	1883	9,262	97	1	6	899,100
1857	7,000	117	0	0	819,000	1884	9,559	84	11	6	808,452
1858	6,491	119	2	0	773,078	1885	9,296	89	7	2	830,668
1859	6,530	131	15	0	860,237	1886	9,241	101	8	6	937,268
1860	6,656	136	3	0	907,216	1887	9,214	113	0	0	1,041,182
1861	7,010	122	5	0	856,972	1888	9,183	117	5	6	1,076,936
1862	7,578	116	0	0	879,188	1889	8.912	96	10	9	860.432
1863	8.300	117	0	0	971,100	1890	9,602	97	13	3	937,760
1864	9,295	107	1	0	995,029	1891	9,353	94	4	1	881,139

Accepting the foregoing figures, we obtain the following approximate averages for the different centuries:

	White Tin.	Black Tin.
13th century	300 tons.	461 tons.
14th "	538 "	828 "
15th "	476 "	732 "
16th "	526 "	809 "
17th century	1,170 tons.	1,800 tons.
18th "	2,560 "	3.938 "
19th "	5,717 "	8,795 "

Sudden advances in the quantity of tin produced are most noticeable in the latter part of the fourteenth century, but they were not maintained. It seems likely that they were caused by the great demand for bell-metal for church-bells at that period. Good bell-metal contains about 20% of tin. The second period of especial advance was in the latter part of the eighteenth century, and was probably occasioned by the common use of bronze for artillery. The third rapid advance was in the present century, and may be said to mark the commencement of what may be called the "canned-provision" period.

In the earlier centuries of the period under consideration the valley gravels, or alluvial deposits, were probably the sources of the greater part of the tin. At the close of the sixteenth century there could not have been more than from 12 to 20 mines proper producing tin, and it is not likely that these were worked simultaneously or continuously. A total production of 400 tons per annum during the sixteenth century would perhaps be an outside estimate, and it must have been greatly less for the preceding three centuries. If we say 400 tons per annum for the sixteenth, 200 for the fifteenth, 100 for the fourteenth, and 50 for the thirteenth century, we reach a total of only 75,000 tons out of 283,000 actually produced, or

say 26%. Of course, these figures are little more than rough guesses; still, it is quite probable that they closely approximate the general averages. In 1837 and 1838 the alluvial deposits did not produce more than two per cent of the whole, but it is certain that the present proportion is much less than one per cent.

In considering the relative proportions yielded by Devon and by Cornwall as a whole, from the figures above given it appears that from 1192 to 1219 Devon produced probably four times as much tin as Cornwall. It is not unlikely that this indicates that Cornwall was less known than Devon. One hundred years later the records still show a greater amount produced in Devon than in Cornwall, whereas in 1337 the production of Devon was not more than one quarter that of Cornwall. In 1602 the Devon production had fallen to about six per cent, and in 1820 to probably less than four per cent, and for several years past it has been less than one half per cent of the total production. With these figures before us it is difficult to say how Devon can be credited with more than an average production, for the whole period of 690 years, of at most 160 tons of black tin yearly; that is, 110,400 tons out of 1,736,300 tons, or but little over 6%.

The principal ore of tin is the binoxide, or cassiterite, a mineral that frequently very closely resembles in appearance the common brown garnet. Pure binoxide of tin, however, is colorless ; it contains 78.32% of tin and 21.68% of oxygen, but in this form it is very scarce.

The common cassiterite contains more or less iron and manganese in the form of oxides, and the quantity of these impurities determines the amount of metallic tin that it contains ; its specific gravity is 6.5–7.1, and its hardness 6–7. Usually in smelting it produces from 65% to 72% of metal. Tin is also found in a metallic state, in small grains, in the alluvial gold deposits of Siberia, Guiana, and Bolivia. Cassiterite is found both in mineral veins and in alluvial deposits. Cornwall presents the best types of the former, but in the East Indies and Australia the alluvial deposits furnish most of the tin.

Cornwall.—The veins from which the ore is obtained in Cornwall occur principally in granite; they are also found in the slate (or killas, as they are locally termed), which usually rests on the granite at a high angle. But in some cases the junction of these two rocks is nearly vertical, and again they are considerably broken and mixed at the point where they come together; and sometimes at these points they are also altered in texture, the granite becoming very fine-grained, and the slate hard and massive. In addition to these rocks in the Cornwall tin district there are numerous dikes of quartz-porphyry, which are known as "elvan courses." These are sometimes only a few feet in width, but generally much wider; they traverse the granite as well as the slate without interruption. The mineral veins traverse the granite, slate, and elvan courses, showing that they were formed posterior to the elvans. It is a common occurrence for the mineral veins to carry copper ores in the slate, and as the granite which underlies the slate is approached tin ore makes its appearance ; eventually, where the main body of granite is penetrated by the vein, the copper gives out entirely, and tin takes its place. Every mineral vein or lode throws off branches and stringers into the adjoining country-rock, sometimes to such an extent that the main lode becomes divided into a complex network of veins. A lode will also dwindle to a mere line, while some of the stringers become enlarged, exceeding in size the parent vein.

In the vicinity of Redruth, Cornwall, are alternations of the granite and slate. At the Tincroft mine the granite goes down to a depth of 156 ft. below the surface, when the slate appears and continues to the depth of 500 ft., at which point the main body of granite reappears. At the Dolcoath mine a large mass of slate rock was met with 380 fathoms below the surface ; this slate is included in the granite 1440 ft. below the point where that rock was first cut into by the workings, and 1860 ft. below the sea-level. This inclosure of slate closely resembles the original slate of that district, and under the microscope their identity becomes apparent.

As already indicated, the principal tin ore of Cornwall is cassiterite: the rock carrying this is broken down from the vein and hoisted to the surface, whence it is carried to the stamp-mills ; the larger lumps are broken by hammers, wielded, for the most part, by women. The ore thus broken, together with the finer ore that has come from the mine, is crushed in the stamp-mills fine enough to pass through a screen containing 40 meshes to an inch, and carried by the water to the dressing-floor, where it is concentrated into "black tin" by an antiquated system of "ties," "buddle," and "dolly tubs."

The "black tin" concentrates contain an average of about 66% of metallic tin, and are mixed with about 20% of pulverized coal and smelted in reverberatory furnaces. The tin in the ore is reduced to a metallic state by this treatment, and is tapped out of the furnace into a cast-iron kettle, from which it is afterward ladled into molds, and the blocks of metal thus obtained are known in commerce as "pig tin."

In earlier times considerable "black tin," or "stream tin," was obtained from the valleys of Cornwall. It was derived from the mineral veins by erosion, and carried down into the valleys and distributed in the sand along the watercourses. Any impurities, such as iron pyrites, that may have existed with the tin were oxidized by exposure to air and water and washed away, leaving the stream tin in a very pure state, and the metallic tin obtained from this was always purer than that obtained from the mineral veins. This source of supply in Cornwall, however, is now exhausted.

TIN IN AUSTRALIA.

Tin is said to have been discovered in Australia as early as 1849; and in March, 1853, "black tin" was found in the black sand brought in from the Victorian gold-fields. Cassiterite was also discovered in New South Wales in 1853. In 1860 a considerable quantity of "stream tin" was obtained from the alluvium at Oban, in the same province. Up to 1867 there had been exported from Victoria 2650 tons of black sand and tin ore and 12,416 lbs. of metallic tin, but the actual mining of the tin was not commenced until 1872. The extent of country throughout which tin is now known to be distributed is very great: the ore is found at intervals along the Australian Cordilleras, but principally upon the western slopes, commencing at Tasmania (which is geologically considered a part of Australia) and ending at Somerset, at the extreme end of Cape York Peninsula, Northern Queensland. As far as is known at present there are three points along this course where the developments of tin have been extensive. First, at Mount Bischoff, in Tasmania; second, along 151° and 152° longitude and from 31° to 38°

south latitude, which, roughly measured, comprises 160 to 180 miles from south to north and 50 to 90 miles from east to west; and third, between 143° and 146° longitude and 15° to 18° south latitude, about 200 miles by 60. In addition to these there are the Mount Wells deposits in South Australia.

The tin granite of Australia appears to be closely allied to that of other countries, and has been described as exactly corresponding to that of Cornwall. Still, it sometimes contains more orthoclase and less tourmaline than the Cornwall granite; in many places there is a total absence of this last-mentioned mineral. The granite from Mount Wells differs from any in New South Wales and Queensland in having mica more abundant and in larger flakes. The sources from which Australian tin is obtained at present are, first, the existing river and creek beds; second, the old buried drifts of the miocene period; and third, the veins in the granite.

The alluvial or gravel deposits are composed of the detritus formed of the eroded granite, and portions of the older drifts which have been cut through by the new river systems and thereby enriched by part of the old accumulations. It is improbable that 20 years' work has discovered, much less worked out, the whole of these alluvial deposits; and it is not possible to predict the quantity that may be obtained from these sources, but it will be very large. Many of the original claims are still being worked, and much of the ground that was worked at first in a very crude way may be worked over again by better and cheaper methods. The beds of the old rivers and creeks underlie nearly the whole of the alluvial drifts, and in consequence many claims which were supposed to be exhausted have been found, by boring, to be richer than ever. These deposits in some places have been buried by outbursts of volcanic lava, which at one time covered a large part of the surrounding country.

New South Wales.—The principal alluvial deposits in New South Wales are situated about 400 miles north of Sydney, on the western slope of the great dividing range. Cassiterite occurs principally in the granite and basaltic country in the extreme north of the colony near Tenterfield and Vegetable Creek, now called Emmaville, and in other districts of New England. It has also been discovered in the Barrier ranges at Poolamacca, near Bombala in the Monaro district, and in the valley of the Lachlan, but none of these deposits has been utilized to any extent. The principal mining centers are at Emmaville and Tingha, in the northern portion of the colony. The deposits occur in the form of lodes and stream tin, and are worked by European and Chinese miners. Heretofore the production has been from the alluvial deposits, but recently (1891) these are said to be practically exhausted. Tin has also been found in veins in the Emmaville district, the principal one being the Ottery mine. At Tingha little or nothing has been done to develop the numerous lodes in the neighborhood.

PRODUCTION OF TIN IN NEW SOUTH WALES.

Year.	Ingot and Ore, Value.	Year.	Ingot and Ore, Value.	Year.	Ingot and Ore, Value.	Year.	Ingot and Ore, Value.
1876*........	£1,032,483	1880........	£354,252	1884........	£281,188	1888......	£309,510
1877........	248,906	1881	568,795	1885........	308,760	1889......	207,670
1879........	256,732	1883........	448,887	1887........	311,889	1891......	133,963
						Total...	£5,675,663

* Period 1872–76, both years inclusive.

Queensland.—The most important tin mines in Queensland are in the Herberton district, southwest of Cairns; at Cooktown, on the Annan and Bloomfield rivers; and at Stanthorpe, on the border of New South Wales. Herberton is the chief tin-mining center of Queensland, and the tin in this district is obtained chiefly from lodes. Out of a total product of 2031 tons in 1890 there were only 341 tons of alluvial tin.

EXPORTS OF TIN ORE FROM QUEENSLAND.

From the Annual Report of the Under Secretary for Mines, 1891 (published 1892).

Year.	Tin Ore.		Year.	Tin Ore.	
	Tons.	Value.		Tons.	Value.
1872	1,407	£109,816	1883	3,346	£187,292
1873	8,938	606,184	1884	3,383	130,460
1874	5,702	358,550	1885	3,253	151,871
1875	4,475	237,879	1886	3,153	162,124
1876	4,315	187,201	1887	3,279	217,389
1877	3,335	133,432	1888	3,586	200,019
1878	2,489	88,366	1889	3,033	156,406
1879	2,877	120,391	1890	2,970	154,963
1880	2,847	142,977	1891	2,236	116,387
1881	3,456	193,699	1892	.....	....
1882	4,261	269,904			

Victoria.—The yield of tin in Victoria is small, and until lately no field of importance had been discovered, but toward the end of 1890 extensive deposits were reported to exist in the Gippsland district, at Omeo and Tarwin. Small deposits have been found in the Beechworth district, at Indigo and Mitta Mitta.

In South Australia and Western Australia tin-mining is unimportant, the yield up to 1891 being slight. In New Zealand no production of tin is officially recorded.

Western Australia.—The following particulars are taken from the *Western Australia Year-book for* 1891, by Malcolm A. C. Fraser, Registrar-General, published in 1892:

Tin was discovered in the latter part of 1888 about nine miles from Bridgetown. The formation of the district is crystalline schists, gneissic and granite rock, with numerous dikes of diorite, granite, and veins of tourmaline. The tin-wash of the field varies greatly in thickness—from 6 in. to 20 ft.—and also in richness. No lodes have been found, but from the crystalline, unwaterworn character of the tin they must exist. The field is in its infancy, and up to the end of 1891 576 tons of tin (presumably ore) had been exported. Tin has also been discovered in the alluvial workings at Pilbarra, but the deposits could not be worked, as the mining regulations for working gold and tin clash, and no large space can be granted in a gold-field.

Tasmania.—Tin ore was found in Tasmania at an early period in the history of the colony, but it was not until 1872 that the great Mount Bischoff property was discovered, and this is now being worked by the Mount Bischoff Mining Company. The tin is found in what is termed euritic porphyry, and the most productive portions of the deposit are situated close to the porphyry and slate. The average yield of this deposit is said to be about 3%, though in many places it yields from 25% to 30%. Although the limits of the ore body do not seem to have been

determined, sufficient ore has been found to last for many years to come. A great amount of money has been expended around the mountain in searching for tin veins, but as yet no well-defined lode has been discovered. Four or five bore-holes have been put down to a depth of from 200 to 300 ft. by a diamond drill, and all have reached a slate formation without disclosing any tin.

The next district in importance is the Ringarooma. The deposits at this place appear to be the bed of an ancient river, running nearly north and south, and covered by a crust of basalt. The depth of the alluvial "wash" at starting was about 6 ft., but it has reached a depth of 140 ft., 30 ft. of the face on top being basalt and the remaining 110 ft. a fine quartzite gravel, containing about three quarters of 1% of tin ore. The mode of working adopted is to bring the alluvium down by hydraulic jets, washing all the fine sand into the tail-race, then by hand sluice-boxes similar to those used at Mouut Bischoff.

In Tasmania, as in New South Wales, nearly all the tin hitherto produced has been from alluvial deposits; the lodes in the vicinity of Heemskirk, Mount Bischoff, and Ben Lomond have remained almost untouched. Considerable areas of alluvial tin grounds in the eastern and northeastern divisions are now (1891) worked out, and the miners will be obliged to turn their attention to the development of the other branch of tin-mining, when it is expected that with a systematic testing of the ground valuable lodes will be discovered.

TIN IN THE EAST INDIES.

Banca, Billiton, etc.—The conspicuous part which the Dutch possessions in the Indian Archipelago have taken in supplying the world with tin is well known. Tin was discovered in Banca in 1710, and it has been produced there ever since; but the supply has been most important since the island came fully into the possession of Holland, in 1821.

In Billiton and the adjoining island of Singkep the existence of tin was known prior to 1822, but the prevailing superstition that tin-mining brought misfortune prevented the development of the industry. In 1851 Mr. C. de Groot, a mining engineer, found considerable tin in Billiton, and active work on the island dates from that time: less than 500 tons were produced during the first ten years, and but 3000 tons in the next decade. In Billiton tin-mining is done by private parties, while 70% of the mines of Banca are controlled by the Dutch Government, which formerly controlled them all. The Banca metal is shipped to the island of Java and exported from the port of Batavia to Holland, figuring in the market as tin exported from Batavia. The tin deposits of Banca and Billiton, the types of the Indian Archipelago, are mainly alluvial, although some lodes supposed to be of recent origin have been worked. The bed-rock of the country is granite, metamorphic slates, quartzites, and sandstones. The cross-section of the Banca deposits would show, following from the bed-rock upward, an average of three feet of tin ore overlaid with coarse sand, followed by red, white, and black clay; then coarse sand with pockets of clay, and layers of fine sand carrying a little tin ore; then humus. The average overburden is from 25 to 30 ft. thick. The tin of Banca and Billiton has been traced to its original sources—the veins in the granite and gneiss. Veins are also found

cutting through the overlying quartz-schists, clay-slates, and clay-sandstones, but very little lode-mining has been profitably done. Only about one quarter of the Banca and Billiton tin requires refining; the "black tin" averages 71% in white metal, and the loss in smelting is given at about 3%.

Messrs. De Monchy & Havelaar, Rotterdam, have kindly furnished me with the following statistics of the production of tin in Banca and Billiton:

Years.	Production of Banca. All sent to Holland and sold there.		Production of Billiton. All sold at Batavia.		Production of Billiton. Of which Holland received	Total Exports of all Descriptions from Holland to United States.
	Picols.*	Average Price, Guilders per 50 Kilos.	Picols.*	Average Price laid down in Holland, Guilders per 50 Kilos.	Picols.*	Tons.
1880–81......	72,685	55.86	78,928	57.17	46,943	166
1881–82	64,190	63.42	66,331	61.10	54,621	86
1882–83......	73,995	56.85	70,081	55.90	53.270	380
1883–84......	65,018	50.65	70,974	48.60	41,511	413
1884–85	74,510	52.81	61,357	52.63	48,147	916
1885–86......	76,552	58.80	81,052	59.31	42,295	473
1886–87......	77,090	68.60	89,192	66.46	46,855	607
1887–88......	84,397	69.48	77,840	62.25	46,211	400
1888–89......	65,964	56.66	79,194	56.42	52,019	403
1889–90.....	89,691	56.80	96,179	56.48	53,042	883
1890–91.....	107,189	54.75	96,488	54.75	47,735	606
1891–92......	(?)	55.91	106,246	56.00	54,574†	660†

* Picol = $61\frac{76}{100}$ kilos. † Estimated.

The Malay Peninsula.—In the Malay Peninsula the Chinese are known to have worked tin diggings as early as 1793. Since then the development has been gradual until a comparatively recent date. In 1866 the exports of the metal amounted to 5692 tons, in 1874 the total was 13,566 tons, in 1883 it was 17,195 tons, and in 1889 it rose to 28,492 tons, an increase of 65% in six years. Similar geological conditions have prevailed in the Malay Peninsula, Banca, Billiton, and Singkep, and as the search is extended this field will presumably be widened. Quartzites, quartz-conglomerate, sandstones, quartzite-schists, hornblende-schists, clay-slates, with granite and local basalts, constitute the prevailing rock formations. In the State of Perak the tin deposits are beds of alluvium varying in extent and thickness, and are composed of layers of sand and clay resting on a tin "wash." This "wash" is found at depths varying from 2 ft. to 35 ft., and varies in thickness from a few inches to 15 ft., producing at different points from ½% to 30% of tin ore. It is composed of waterworn fragments of quartzite and granite, which characterize the tin-producing layers. Tourmaline is one of the constituents, and is present in greater quantities than is usual in Cornwall or Tasmania. With a few exceptions, the "black tin" is free from pyrites and other objectionable minerals, and besides the black tin ore white cassiterite is a frequent occurrence; red or ruby ore is also found. Attention here, as in other parts of the East Indies, has been almost entirely devoted to the alluvial tin; the lodes are not being worked, though their existence is known.

Perak * now produces annually 14,534 tons of metallic tin, worth, roughly,

* Extracts from a paper entitled "Mining in Perak," by E. R. Pike, Inspector of Mines at Kinta, in vol. iii. of the *Transactions of the Mining Association and Institute of Cornwall.*

£1,310,000. This is two thirds of the whole production of the Straits, and a third of that of the world. The whole of this tin is produced in different parts of the State, which could easily be included within a 20-mile square. Taking the district of Kinta as an example, in a belt of country six miles long by two miles broad, where work has been going on for four years, probably not one and a half square miles have been properly worked out. From this small tract of country fully £1,000,000 worth of tin has been extracted.

The general aspect of Perak is hilly, except in close proximity to the sea; there is a main range, rising to a height of 8000 ft., running north and south, which divides Perak from the neighboring States of Kelantan and Pahang. This main range is composed of highly metamorphic rocks, intersected by veins of volcanic origin, which seem to have been forced through the older formation of limestone. This limestone in a great number of cases seems to form the bed-rock on which the tin-wash has been deposited—whether before or after the intrusion of the granite it is hard to say, though alluvial deposits of similar nature to those in the valleys have been found 1500 ft. up in the caves on the limestone hills.

The tin-wash is found at the foot of the main ranges, and is generally richest in tin at a distance of half a mile from the hills. In some districts the bed-rock is limestone, such being the case in the Kinta district, which is now producing two thirds of the tin of the State. In the Larut district, which has been very rich, but is now getting worked out, the bottom is principally pipe-clay of various colors: this apparently rests on the granite, and in some of the more northern valleys on limestone and slate. The bottom of a mine is very often composed of lodestuff; in fact, more than half of the lodes discovered are found in the bottom of the Chinese mines. In the districts where pipe-clay, or decomposed granite, forms the bottom, the deposit of tin-wash is very even, and often of uniform richness in areas covering several acres. In the limestone district the wash is very irregular, in some cases rising up to within 3 ft. or 4 ft. of the surface, and then, 10 yards off, going down to 30 ft. or 40 ft. in depth. It is in the holes in the limestone bottom that the richest wash is obtained: one mine about 20 yards square was opened in a big valley, and from this small hole £6000 worth of tin was raised in three months by 30 men. This mine was about 25 ft. deep, and no rich wash was found on either side of it. Tin is generally found in the valleys: these are usually very swampy, so a big trench is dug some six feet deep to drain off the surface-water; the timber is then felled and the paddock is marked off. The overburden is taken off by contractors, who get paid about £1 per chang (which is 30 ft. square by 1½ ft. deep). The size of a mine is measured by these changs, so that if a mine were 30 changs in size and 30 ft. deep it would cost £600 to remove the overburden. When this has been done, men are engaged at about 13d. and board a day to bring up the wash, which is generally put in a big heap and left to dry in the sun; by this means a lot of the clay becomes friable, and no puddling is required. Puddling is a very expensive process, and generally ends in a considerable loss of time. When all the wash has been brought to the surface, a wooden box is made about 30 ft. long, with a fall of about 1 in 10, according to the class of stuff to be washed. The washing is performed by shoveling the stuff into the box and allowing a stream of water to run over it, and agitating it by means of long hoes. The stuff is all

brought up in baskets, strung two on a stick and carried on the shoulder. When working for himself, a Chinaman will bring up 180 lbs. in one journey; on the other hand, if working on day wages, it takes a lot of persuasion to make the same man carry 30 lbs., even in the Chinese mines.

The foregoing remarks relate to Chinese methods of working, but tin-mining has been carried on in the Malay Peninsula by Malays for some 400 years. Ships in the time of Queen Elizabeth used to trade with the Dutch for tin in Malacca, which is the oldest town in the peninsula. Malays in mining do not look for tin at great depth, but generally confine themselves to the high land at the foot of the big hills: they begin by diverting a stream, and, when it is possible, running it at a height and allowing it to drop on to the face they want to work. The water falling on the soil disintegrates it; the stuff then runs into long sluices with riffles, and is continually stirred up with spades to prevent caking; when the gravel is nearly run off, the residue is taken out and washed, sometimes in pans and sometimes in short boxes. By this method land containing a very small quantity of ore can be washed at a profit; in fact, this way of working is very similar to the hydraulicking in California. A large tract of country has been mined in this way by Malays; and from bits of ground which are now left standing it may be reckoned that at least 5 square miles of country, with a depth of from 15 to 40 ft., have been thus washed away. In some cases tin in large quantities has been found deeper down, and underneath the high ground formerly worked by Malays. There is still some land of this description left, and some of it has been taken up by European companies, who are going to work it by the American system of hydraulicking, which is being used with such success in connection with the poorer gold deposits of California.

Lodes have been recently discovered in the State. In Kinta these lodes mostly occur in the limestone, and yield copper, sulphur, iron, arsenic, and tin. Up to the present no great depth has been reached, but from the surface down to 30 ft. most of the lodes give great promise of being rich in tin.

Land can be obtained from the Government on a 21-years lease, and *bona-fide* work must be commenced within six months, an average of two men per acre to be employed, unless the land is too poor to warrant such expense. All water and watercourses are the property of the Government, and on new land sufficient water to wash with is given out by the inspector of mines.

The duty on tin collected by the Government is 10% and is paid at every seaport town. Transport rate from the inland mining district is very high, but the Government is now making roads and railways, and in another year or so tin will be produced at a much cheaper rate. The present price (March, 1891) of slab tin at a mine in Kinta is about £72 a ton, or 25% below the market rate.

Tin is smelted in small furnaces used with a blast, charcoal being universally used as fuel. Great damage is done to fine timber by the promiscuous burning of valuable woods. A company has been started in Singapore, within the last three or four years, which is buying a great deal of ore from the Chinese in Kinta and smelting it in Singapore. A better percentage for the ore is given than the Chinese can get from their own furnaces, as only reverberatory furnaces can be used. This company smelts more tin annually than the whole production of Cornwall.

The Island of Sumatra.—Attention has recently been directed to a tin field on the island of Sumatra within the district of Siak. Sumatra is divided longitudinally by volcanic ranges into the east and west coast country. The west coast is a narrow strip of land from 20 to 30 miles wide, underlaid with granite; in places it is covered with alluvium and coral formation, sandstones, slates, and volcanic rocks. East Sumatra is a generally low and slightly undulating country, of the geology of which little is known. The tin fields are approached by steamers running from Singapore across the Straits of Malacca to Brewer Straits, up the Siak River to Benkalic, thence south to Siak. As compared with Banca, Billiton, and other tin-producing localities in the East Indies, the tin fields of Sumatra are extremely inaccessible; the density of the vegetation makes prospecting very difficult, and almost every line explored has to be previously cleared by bushmen. The distribution of the cassiterite through the creek beds of this district is somewhat unusual in character. One would expect to find the fine ore down-stream and the coarse ore up-stream, according to the laws governing the distribution of sediments; but here there is found a perceptible decrease in the average size of the grains going up-stream within a certain limit or belt; going beyond this limit there is a positive decrease both in the coarseness and the quantity of the tin grains. The pay-gravel beds average one per cent in metallic tin. In comparing the richness of the alluvial deposits of this new tin field with those of the island of Banca, it is found that the former yields at the rate of 0.348 lb. of tin per cubic meter excavated as against a yield of from 3 to 4½ lbs. in the latter. The relative proportion of pay-gravel to entire stratum removed is practically the same in both districts.

The black tin obtained from this district is smelted at Singapore, in furnaces similar to those used in Cornwall, and by the Chinese in their local camps. At Singapore the charges for smelting are as follows: Ore assaying 70% and over, gross price $25.20 per ton; 65% and over, $29.40 per ton; 60% and over, $33.60 per ton.

Ores containing sulphur, copper or iron pyrites, arsenic, or other impurities requiring special treatment, pay a higher charge. Deductions for trifling impurities usually vary from 0.2 to 0.5 unit, and for smelting losses the deductions are: On ore assaying 70% and upward, deduction 2 units; 65% and upward, 3 units; 62% and upward, 4 units; 60% and upward, 5 units.

For example, on a high-class ore, assaying say 74.2% of tin, there would probably be deducted 0.2 for impurities and 2 units for loss in furnace, leaving 72% net refined tin. On ore assaying 72% and quite pure, possibly 70% net refined tin would be allowed, but more likely 69½%. It will be seen that the losses thus charged are very severe when the ore falls below a 70% grade. Assuming the deduction for impurities at 0.5 unit, the losses charged really are: For ore assaying 70% and over, 3.57%; 65% and over, 8.46%; 62% and over, 10.46%; 60% and over, 12.50%.

In regard to the export of tin from the East Indies, it may be said that what is known to the trade as Singapore tin comes partly from Perak, partly from Sungi, Ujong, Selangor, Kwalla Lumper, Jelubu, and Malacca. What is known as Penang tin is all from Perak; and what is known as Straits tin in London is Penang and Singapore tin. What is known as Malacca tin in the United States is also

Penang and Singapore tin, only it is specially branded to suit the American buyers. The shipping rates from Singapore in September, 1890, were about as follows: To Holland, 15s. per ton; to the United States, 21s.; to London, 7s. 6d. Insurance costs ½% to ⅝%.

EXPORTS OF TIN FROM SINGAPORE AND PENANG.
In pikols = 133⅓ lbs.

Year.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
From Singapore to									To Oct. 18,
The United States	44,354	28,315	41,693	55,760	52,075	92,949	97,901	122,662	108,0[illegible]3
Great Britain	87,072	82,641	52,367	134,585	174,682	161,672	159,217	148,105	81,570
Continent of Europe	8,971	8,850	29,783	27,665	22,111	61,462	67,678	72,768	73,505
India	......	918	2,865	2,465	772	813	2,518	2,590	} 6,846
China	....	4,180	4,895	2,214	3,319	3,616	3,365	3,368	
Total from Singapore	....	124,904	131,603	222,689	252,959	320,512	330,674	349,488	....
From Penang to									To Oct. 20,
The United States	20,592	21,934	50,894	15,989	11,105	40,289	20,599	40,545	34,493
Great Britain	132,824	146,129	151,236	161,715	141,214	119,670	111,558	138,682	144,042
Continent of Europe	992	1,344	3,059	4,353	338	1,432	3,195	8,323	8,405
									To Oct. 19,
India	... .	22,388	25,144	15,792	21,351	22,543	28,690	25,042	16,314
China	... .	37,810	37,966	37,382	59,946	40,831	46,733	37,656	21,576
Singapore	....	11,135	9,658	....	....	....	....	....	25,889
Total from Penang	......	229,605	268,299	235,231	233,954	224,765	210,775	250,248	
Grand total	....	354,509	399,902	457,920	486 913	545,277	541,449	599,736	
In tons of 2000 lbs	....	23,624	26,660	30,528	32,461	36,352	36,097	39,982	

The above table is compiled from reports of Messrs. Boustead & Co., London, Penang, and Singapore.

Burmah.—The tin-bearing deposits in Burmah * are, according to Mr. H. Warth, of the Government Central Museum, Madras, of two kinds: First, there is the tin gravel which is found in all or most of the valleys, a mixture of rough white quartz pebbles with sand, garnet, black tourmaline, and gray cassiterite. The thickness of the gravel varies from one foot to six feet, and the yield of cassiterite may be put down as at least one fourth per cent, or five pounds of cassiterite per ton of gravel. There are washings going on at many places, but some valleys have been more or less exhausted. The work suffers also under the disadvantages that the greater part of the country is uninhabited, that food has to be brought from a distance, and that there is always danger of sickness. Chinamen are the chief workers. The second kind of tin-bearing deposit is the original eruptive rock, which is weathered so that it is possible to wash out the grains of whitish cassiterite which it contains. Mr. Warth visited the principal deposits of this kind near Malewun in July, 1891. The yield is only 0.04% of impure wash tin.

TIN IN SOUTH AMERICA.

Probably no tin deposits of consequence have been found either in Peru or in Chile, but they are of frequent occurrence in Bolivia, in an extensive silver and tin mineral belt about 250 miles long, running nearly north and south through the mountains bordering the great interior plateau on the east. Heretofore the development of tin-mining in Bolivia has been prevented by lack of railroad facilities, but within the past year a 200-mile extension of the Antofagasta Railroad (narrow-gauge) has been completed from the former terminus at Uyuni northward to Oruro, and as it runs north, parallel with the tin belt, it is probable that the production of this metal will be greatly stimulated. Tin has long been mined in a small way in Bolivia, the inferior grades often being produced as a by-

* *Engineering and Mining Journal*, Nov. 5, 1892.

product from some of the silver mines—for example, at Oruro, Potosi, and Porco. The purest of Bolivian bar tin comes from the Chorolque smelting-works, about 50 miles east of the railroad at Uyuni. At Potosi tin ore is found in large quantities in veins of silver. At Chorolque bismuth and tin are found close together in distinct veins. In the old mines of Porco, 35 miles south of Potosi, tin and silver are intimately associated, and in some cases there is a remarkable occurrence of both metals in distinct layers or bands in the same vein. In many deposits tin is disseminated in the soft clay gangue; in others it is found in small quantities intimately associated with iron pyrites. A few deposits of alluvial or stream tin have been discovered, but only one that is of any importance. Only in rare cases are the tin deposits worked systematically. All the tin that is exported goes to England, the bulk of it being shipped from the Pacific ports of Mollendo, Arica, and Antofagasta.

The tin veins of Bolivia are said to be found in porphyritic diorite, which has broken up through sandstones and conglomerates; in trachyte, breaking through slates; and also in slates and quartzites. The tin produced in Bolivia is exported to England, and from 1883 to 1892 the amounts shipped yearly were as follows: *

1883......493 tons.	1886...... 354 tons.	1889......1,389 tons.	1892 (*a*)......1,525 tons.
1884......204 "	1887...... 982 "	1890 ......1,664 "	
1885......224 "	1888......1,363 "	1891......1,559 "	(*a*) First six months.

THE TIN DEPOSITS OF MEXICO.

Tin stone has been found in Mexico at numerous widely separated localities, among which may be mentioned Durango, Cacaria, Potrillos, and Sain, in the State of Durango; Chalchiuites, in Zacatecas; Bolaños, in Jalisco; Cerro de Zamorano, in Queretaro; Cerro del Chiquihuite, in Aguas Calientes; and some places in the State of Guanajuato. None of these deposits has been systematically or extensively exploited, with the exception of those of Durango, where the ore is found to occur in small but frequently very rich pockets in ill-defined veins in trachyte-porphyry, which is the common country-rock.

From all accounts the cassiterite of the other States occurs in much the same manner, though in some places it appears in the form of concretions irregularly scattered through the country-rock. Don Mariano Bárcena, speaking of the igneous rocks of Mexico in his *Tratado de Geologia*, says: "It is to be noted with respect to the volcanic porphyries of Mexico that in many instances they present characteristics indicative of hydrothermal origin, or at least that when they appeared they were plastic because of the water that impregnated them, since there are to be observed in them many undulating lines of hydrosilica and other substances, which seem to mark the direction of fluidal currents; thus are to be noted in these porphyries concretions of opal, hyalite, and also oxides of iron and tin, which are, without doubt, of hydrothermal origin."

Deposits of stream tin are found in the "arroyo" bottoms in the vicinity of the lodes, and these have been worked by the natives in a desultory manner for many years—in some places, indeed, since the beginning of the present century. These

* *Engineering and Mining Journal*, Sept. 3, 1892.

alluvial beds are, however, of small extent, and their exploitation on a large scale would be difficult, owing to the character of the country. Many of the more accessible bottoms—those at Cacaria, for instance—have already been exhausted by native "buscones" and "gambucinos."

It is impossible to arrive at any statistics of either the past or the present production of tin in Mexico, with the exception of 25 tons of pig tin that were smelted by the Pittsburg and Mexican Tin Mining Company in 1891 and shipped to the United States. All the mineral that has been produced has been won by the natives in small lots, and reduced in diminutive and rude stone shaft furnaces at the mines. Shipments of tin smelted in this manner were made from Durango as early as 1845, and some of it has been sent across the mountains to Mazatlan and thence to San Francisco, but the amount is insignificant.

TIN IN THE UNITED STATES.

California.—The discovery of tin in the United States may be said to date as far back as 1840. Tradition states that early in that year Indians discovered tin ore in Southern California. The discovery was made on a property then known as the Rancho Sobrante de San Jacinto, a Spanish grant, situated in what is now San Bernardino County. Later the Mexicans are said to have ascertained, either from the Indians or as a result of their own prospecting, that the property contained veins rich in what they supposed was silver, for such they called the white metal which they smelted from some of the ore. Still later the whites learned of the ore discoveries in that vicinity. There was a rush of people to the new district, and several hundred mineral locations are said to have been made. In 1868 a party of San Francisco capitalists organized the San Jacinto Tin-mining Company, which acquired possession of the Spanish grant. The present property consists of about 45,000 acres, or 70 square miles, situated a few miles south of the town of Riverside. Owing to the supposed value of the property and to the uncertainty as to its rightful ownership, a suit was instituted to obtain possession of some of the mineral veins. The company, however, commenced mining operations at once, and, it is said, expended about $100,000. Some of the richest ore was sent to San Francisco, where it was smelted, and several tons of tin were obtained. A part of this, together with articles of tinware, etc., made from it, was exhibited at the Mechanics' Fair held in San Francisco in 1869.

As the work at the mine was not profitable it was closed down, but the litigation in regard to the ownership of the property was continued until the United States Supreme Court finally confirmed the title to the San Jacinto Mining Company in March, 1888. Several attempts were made to sell the property after the mining operations were suspended in 1870, but without success until August 6, 1890, when it was transferred to an English corporation called the San Jacinto Estate, Limited.

Upon taking possession the English company erected elaborate offices and dwellings and two large hoisting-works. An expensive but useless dam was nearly completed, and dressed-stone foundations for a concentrating and smelting plant were laid.

In the early days of the San Jacinto Mining Company only one vein, called the Cajalco, was worked, and this was developed to a depth of about 150 ft., with about 1100 ft. in all of development work. The actual quantity of "pay" ore in sight when the English company took possession was barely 3000 tons. Subsequent work increased this amount, but a great deal of ore was mined and milled that contained only one per cent, or less, of tin. Altogether probably 6000 tons were milled, from which about 120 tons of tin were obtained, showing an average of possibly 2% of metal.

After the expenditure of a sum said to be $800,000 (including $450,000 in the purchase of the property), the mine was closed down in September, 1892. Recent examinations by tin experts (sent out from Cornwall, it is stated) have resulted in an attempt on the part of the company to raise a considerable fund for the prosecution of development work alone. If this is so, it is a step in the right direction, since heretofore altogether too much has been taken for granted in regard to the quantity and richness of the ore.

The San Jacinto Estate, Limited, made its first shipment of pig tin, of 398 bars or ingots, weighing 22,758 lbs., on June 30, 1891. From that time up to the closing of the mine (September, 1892) a total of about 269,000 lbs. of pig tin, valued at about $56,000, has been produced.

The geology of the tin district in California is similar in many respects to that of Cornwall, the productive veins being found in the granite. In addition to the granite there are porphyry, quartz-porphyry or elvans, quartzite, and slates. The total number of veins so far discovered on the property is about 50; the croppings of all consist of a mottled (black and white) rock composed of quartz, feldspar, and tourmaline similar to the "tin capel" or lode granite of Cornwall. Some of the veins are found in the granite, some in the porphyry, and some extend out into the slate. Several of those in the porphyry have been developed by inclined shafts to a depth of 60 ft. or more, but without showing any encouraging results. It is not definitely known how many veins are in the granite, but only the Cajalco has been worked to any extent. Tin has been found in the croppings of several, but they have not been developed sufficiently to show their value. It is an unfavorable indication that in the gulches and ravines no "stream tin" has been found. From the previous descriptions of the tin deposits of other countries it will have been noticed that the "stream tin," or alluvial deposits, were discovered before the mineral veins; but whether the absence of this almost universal indication of the existence of tin-bearing veins will prove that the veins of the California property do not contain tin in paying quantities remains to be seen. The Cajalco lode is certainly a strong one, and it hardly seems probable that the body of ore that was worked out is all that it contained.

South Dakota.—The discovery of tin ore in the Black Hills was made in 1879; at least in that year Mr. Richard Pearce, then manager of the Boston and Colorado Works at Black Hawk, Col., recognized grains of tin stone in sand sent him from South Dakota. It was first found in place in 1883 in the vicinity of Harney Peak, an intrusion of granite 7442 ft. high, which forms the core of the great uplift of rock at that point. Immediately surrounding this peak is a region of metamorphic slates and schists, which in turn is bordered by the various sedimentary

rocks up to the Cretaceous, lying in rudely concentric rings of varying width, and dipping away on all sides from the central peak. The area of tin-bearing rocks is found to extend to the granite district lying west and south of Custer City, and throughout the Nigger Hill district, which is west of Deadwood and extends into Wyoming.

As in most of the tin districts of the world, tin was first found in the Black Hills as stream tin, but it was very soon traced to its original source in the granite. This granite is generally very coarsely crystalline, and contains besides the specks of cassiterite numerous crystals of tourmaline, columbite, and tantalite, which so closely resemble tin that at first these veins were supposed to carry a much greater amount of tin than was subsequently proved to be the case. As a result of investigation, the tin-bearing rock was narrowed to the granitic, or greisen, dikes which are found in that district, and to the metamorphic slates and schists associated with quartz in veins that are thought to be simply local segregations of ore. The history of the Black Hills deposits may be summarized as follows: A great many mining claims were located and acquired in various ways, ostensibly with the view of controlling all the deposits of any value in that district. By means of exaggerated representations as to the quantity and richness of the ore, large amounts of money were obtained and used in various ways in connection with the enterprise. Ultimately an English company was organized in 1887, with a capital of $10,000,000, with the view of acquiring most of these claims, and the stock was offered for sale on the English market; but the extravagance of the representations of value made were so fully exposed in the *Engineering and Mining Journal* that the securities of the company were not sold. Then four commissioners were sent from London to inspect the properties; and though their report was not altogether favorable, a development fund, said to amount to $1,500,000, was raised, and has since been expended without showing any paying mines. Some of the mines were described in a report by Capt. Josiah Thomas of the Dolcoath mine, Cornwall, dated August 11, 1892. The property of the Harney Peak Consolidated Tin Company, Limited, consists of about 1100 mineral claims, each 1500 by 300 ft. The claims extend over a total length of about 30 miles, in a somewhat circular form for upward of three quarters of the distance around Harney Peak. Captain Thomas speaks of one or two claims as making a very good showing, and several others "promise" to turn out well if developed, but the majority of those he examined were practically worthless. The average of the samples that he took shows that the ore will yield less than 40 lbs. of black tin to the ton, or 1.3% metallic tin. This represents an average value of but $5.20 per ton of ore, which, it is hardly necessary to say, is too little to enable the ores to be worked at a profit. The total amount of ore in sight Captain Thomas estimates to be about 90,000 tons; at $5.20 per ton this would represent a gross value of $468,000, but it will in all probability cost a great deal more than this to mine and mill it and to smelt and market the tin.

There is excellent reason to believe that Captain Thomas's estimates are far too favorable.

While it is possible that further development may disclose tin ore in paying quantities and quality, it cannot be said that this is now the case. No reliable data are obtainable as to the total quantity of tin produced in the Black Hills. Only

a very small amount—probably not 10 tons of metal, including that contained in the various samples sent away from the properties—has yet been smelted from the South Dakota ores.

What has been said of the Harney Peak district will apply substantially, as regards geology and character and richness of the ore, to the Nigger Hill district.

North Carolina.—Tin was discovered at King's Mountain in North Carolina about 10 years ago; it was found as crystals of cassiterite. The village of King's Mountain is situated upon a ridge at an elevation 1200 ft. above tide-water, nearly upon the dividing line between the old Silurian limestones on the east and the granite on the west. The granite shades into mica-schists, then into talcose slates and quartzites, and then into metamorphic limestone, as one travels toward the east. Running parallel to the King's Mountain range on a course east by north, for some 8 or 10 miles above King's Mountain and 30 miles or more below it, are narrow outcrops of greisen, which for the most part conform to the bedding of the country-rock, but occasionally for a short distance take a course at almost right angles to it. These greisen masses vary from a few feet to 600 ft. in width, and being harder than the neighboring schists, they have better withstood the weathering. They stand out prominently, and are almost identical with the greisen of the Black Hills, S. D. The ridge can be followed for miles, and occasionally float rock rich in cassiterite is found—sometimes in isolated lumps, and again so thickly scattered over the surface that many tons could be picked up without much trouble. The deposit has been tested somewhat extensively at a distance of six or seven miles from the village, by open cuts and shafts and with a diamond drill. The latter showed that the greisen existed apparently in large irregular-bedded masses, the vertical extent of which was in no way determinable by their appearance on the surface. They are bedded deposits, though at times, from local causes, they have the appearance of fissure veins. The developments made here by the diamond drill disclose layers or sheets of greisen, greisen and slate, slate and greisen, etc., indefinitely. The explorations by cuts and shafts have also produced results similar to those reported from the Black Hills; that is to say, cassiterite is irregularly scattered through the greisen. In some places the latter is absolutely barren; in others the shaft would go down through many feet of very rich rock. As a result of these investigations it was shown that there are enormous quantities of low-grade ore available, and that with intelligent supervision there will be little difficulty in hand-picking ore up to the grade of one per cent metallic tin. The climate of this district is very favorable to the disintegration of the rocks, and as a result the small gullies running down the sides of the ledge contain much stream tin in places. It is possible that these alluvial deposits might be made to pay by hydraulicking, but there is no head of water in the vicinity. The cost of labor in this district is about $1.25 per day, and the climate is favorable for work the entire year. Fuel is also very cheap, yet in spite of these advantages it seems doubtful if the ore could be mined at a profit. The total output of tin ore that has been shipped from this district is inconsiderable, amounting to a very few tons only, for assay purposes.

Virginia.—The existence of tin ore in Virginia has been known for about 10 years. It was found at the head waters of Irish Creek, on the western slope of

the Blue Ridge Mountains, in the extreme easterly corner of Rockbridge County. The district is very rugged, and has an altitude of from 2400 to 2700 ft. above tide-water, with the general conditions favorable for economical mining. The nearest railroad station, Vesuvius, on the Shenandoah Valley branch of the Norfolk and Western Railroad, is seven miles distant. This section of the Blue Ridge Mountains consists principally of massive and often very coarsely crystalline granite, with outlying patches of slate; no greisen is found. The sedimentary rocks of the Potsdam period are extensively developed, lying between the granite just mentioned and the limestone of the Shenandoah Valley. The granite is traversed by frequent dikes of trap, but the granite itself is the only rock that appears to be related in any important way to the tin ore. There are three principal deposits or veins thus far discovered. In the first or most important one there is a streak of quartz, 8 or 10 in. wide on the foot-wall side, which carries from 1 to 2 in. of cassiterite, having associated with it more or less mispickel (arsenical iron pyrites). Cassiterite is also found in the vein in grains from the size of a pin-head up to masses a foot or so in diameter, and lumps of ore of various sizes are more or less plentiful in the ravine. The developments consist of an open cut extending about 60 ft. into the face of the hill, and a tunnel, or adit on the vein, which penetrates some 40 ft. further; there are also several pits and open cuts on other veins. A mill, said to have cost about $50,000, was erected on the property, and experimental tests of the ore were made, 90 tons of which assayed 3.44% of metallic tin, the concentrates from which assayed 43.44% of tin. A second test was made on 75 tons of ore assaying 3.28% of tin, the concentrates showing 40.40% of tin. The third test was made on 125 tons of ore, which assayed 3.26% of tin, and the concentrates gave 45.07% of tin. The low grade of the concentrates is due to the presence of arsenical pyrites and ilmenite, or titaniferous iron. The average width of the vein from which the ore was obtained for these tests is said to be about six feet. The cassiterite extends out into the granite on each side of the vein, but in such small quantities that it will not pay to work beyond the distance above mentioned. From all the reports available it would seem that this deposit is worthy of further development; but the title to the property is so imperfect, and there are so many adverse claimants to it, that it will probably be some time before it can be satisfactorily adjusted.

Alabama.—Tin is found near Ashland, in Clay County, Alabama, in what are called the Broad Arrow mines; the ore occurs both in lodes and as "stream tin." The country-rock is said to be the micaceous and talcose schist, and the tin ore is disseminated in gneiss, which forms seams from 10 to 20 ft. thick in the country-rock. In a space 800 ft. wide there are 6 parallel and nearly vertical belts of stanniferous gneiss; the amount of black tin in the ore was said to average about 1½%. The work began at the Broad Arrow mines on March 1, 1883, but the operations of the company do not seem to have been successful, for in July of that year work was stopped.

The ore is reported to exist in considerable quantities, but the metal seems to have been a mixture of iron and tin. Cassiterite is said to have been found in the stream which crossed the lodes, but it was so mixed with titaniferous iron that the tin could not be obtained in a state sufficiently pure to be marketable.

Very pure specimens of tin ore have been found also near Rockford, in Coosa

County, in association with tourmaline, biotite, and tantalite. It was discovered here in 1880 by Dr. Eugene A. Smith, State Geologist. See *Bulletin No. 1, Alabama Geological Survey,* for an account of the Coosa County tin.

BLOCK-TIN IMPORTED INTO THE UNITED STATES.

Year.	Pounds.	Dollars.	Fiscal Year Ending	Year.	Pounds.	Dollars.	Fiscal Year Ending
1867	....	1,210,354	June 30	1880	32,480,662	6,153,005	June 30
1868	....	1,454,327	"	1881	19,168,352	3,971,756	"
1869	9,050,852	1,709,385	"	1882	22,124,928	5,204,251	"
1870	9,150,624	2,042,887	"	1883	42,201,780	9,505,949	Up to Dec. 31
1871	11,938,640	2,938,409	"	1884	25,203,379	4,706,273	Calendar years
1872	11,424,672	3,033,837	"	1885	23,535,488	4,497,499	" "
1873	14,612,528	3,938,032	"	1886	29,531,355	6,728,908	" "
1874	13,041,504	3,199,807	"	1887	29,344,553	6,921,948	" "
1875	11,525,248	3,329,487	"	1888	34,294,135	8,802,854	" "
1876	10,435,600	1,816,506	"	1889	35,177,648	7,044,939	" "
1877	10,999,408	1,783,765	"	1890	33,821,319	6,869,645	" "
1878	14,431,088	2,167,350	"	1891	41,146,123	8,091,363	" "
1879	16,007,712	2,301,944	"	1892	46,821,958	9,415,889	" "

The above table is compiled from United States Custom-house reports.

TIN AND TERNE PLATE AND TAGGERS TIN IMPORTED INTO THE UNITED STATES.

Year.	Pounds.	Dollars.	Fiscal Year Ending	Year.	Pounds.	Dollars.	Fiscal Year Ending
1867	....	6,276,136	June 30	1880	369,435,844	16,524,590	June 30
1868	....	6,893,072	"	1881	377,072,728	14,641,057	"
1869	171,844,288	8,565,432	"	1882	439,746,895	16,550,834	"
1870	149,312,800	7,628,871	"	1883	742,807,258	27,194,574	Up to Dec. 31
1871	174,274,576	9,490,778	"	1884	484,245,265	16,858,650	Calendar years
1872	181,174,224	10,736,906	"	1885	512,056,092	15,991,152	" "
1873	207,955,072	15,906,446	"	1886	577,217,362	17,495,564	" "
1874	174,032,320	13,322,976	"	1887	635,792,760	18,699,145	" "
1875	172,547,118	12,557,630	"	1888	667,231,988	19,752,180	" "
1876	197,927,509	10,226,802	"	1889	724,135,688	21,726,707	" "
1877	222,307,980	9,818,069	"	1890	737,935,079	23,670,158	" "
1878	242,646,871	9,893,639	"	1891	734,425,267	25,900,305	" "
1879	278,544,822	10,248,720	"	1892	600,819,566	17,105,475	" "

The above table is compiled from United States Custom-house reports.

NOTE.—In preparing this paper the following publications were consulted in addition to those mentioned in the body of the article: *Transactions of the Mining Association and Institute of Cornwall*, 1885-87; *Tin Deposits of Perak*, J. H. Hampton; *Tin-mining in Tasmania*, James Rowe; *Australian Tin Deposits*, Stephen S. Vaile; *Transactions of the American Institute of Mining Engineers*, vol. xx.; *The Alluvial Tin Deposits of Siak, Sumatra*, Charles M. Rolker, E.M.; *The Vegetable Creek* (Australia) *Tin Deposits*, Wilkinson; *Ore Deposits*, J. A. Phillips; the *Engineering and Mining Journal*. Valuable information relating to Bolivia, Peru, and Chile was also furnished by Mr. Robert Peele, Jr., and about Mexico by W. R. Ingalls, E.M.

Tin Market in 1892.

During the year the interest of the trade was principally centered in the question whether the duty of 4c. would, in accordance with the requirements of the act covering it, actually become operative July 1, 1893. Beside this all else lost more or less of its significance—even the large decline in silver during the first three months of the year, which under other circumstances would have largely influenced the metal.

Several plants for the manufacture of terne and tin plates have been started up, the latter more as experiments, and the former have not amounted to as much as might reasonably have been expected from all the talk that has been current in past times. Anyhow, the works that did come into existence had no effect on the consumption, and throughout the year deliveries of tin have been heavy, the regular trade taking a proportion even larger than that of former years—a sure indication that business generally in all metals was quite good.

With the extraordinarily cheap money market during the first part of the year some of the larger importers commenced to buy, for shipment from the East, somewhat larger quantities of tin than usual, intending to accumulate stocks slowly prior to the time when it might be expected that the duty that was in sight would cause an advance, the same as with tin plates a year or two ago. It was this movement that prevented the market from declining as it would naturally have done in consequence of the decline in silver; and to an extent it actually stiffened rates, so that throughout the year the Chinese certainly received exceedingly good value for their metal.

It was hardly expected that any such movement as we have noticed above would be inaugurated before the fall months, but in April some important London speculators commenced to manipulate things, with the result that the returns must have shown a handsome profit to them. The year opened with a price of 20c. per lb. quoted in New York, and during the first three months the market remained flat, prices slightly declining, the lowest point reached being 19.60c. At the end of March the 20c. mark, however, was again touched. During all this time there was heavy buying being done in the East, to the mystification of the trade, which could easily supply what was wanted at prices slightly lower than those at which the metal at the smelters' was sold; but in April a greater interest was evinced, and slowly but surely prices advanced to 20½c., and then commenced the great movement. It was very soon found out that nearly all the available supplies were centered in the hands of a few strong parties; spot tin consequently was exceedingly scarce in the open market, and futures commanded high premiums, the duty daily becoming more and more of a prospective reality. The decline in silver was entirely ignored, and during May prices advanced 1c. a pound, to 21½c. for spot and 22c. for futures; but not until the 18th of June, when tin for the first six months of 1893 was freely selling at 22¾c., was the full force of the movement felt. Continually, during the rise, heavy quantities of tin were unloaded by the shrewd speculators on their less fortunate brethren, and upon the consumers, who purchased quite heavily.

Then occurred several things which helped to bring down values just as quickly as they had gone up: the previously favorable statistics suddenly became unfavorable, the London market was hammered down, and in the beginning of July values in New York were but about 21c. for spot, and say half a cent more for futures. Then the House of Representatives passed an act repealing the bill levying the duty of 4c. on tin; and although it was generally conceded that there was no chance of the Senate, much less the President, concurring, the position of the metal was in itself so shaky that a considerable further drop immediately took place, and it sold on the spot at 20.45c., that for delivery in October to December at 20.75c., and for the first six months of 1893 at about 21½c., with very little business doing. Every one seemed disgusted, and found himself saddled with dear tin. The movement was described as having been premature, and the promise made that, so far as the rise was concerned, it would be repeated at a later date; but meanwhile the trade generally had lost heart, and it was only the deliveries and the fact that the duty would undoubtedly be levied for a while at least that prevented a more serious decline. In the latter part of July and during August and September there was not much of a change; values often were irregular and tending downward, 20.20c. being the ruling price at the end of the last month named. Up to this time the approaching Presidential election had not at all disturbed business; but gradually more and more attention was paid to it, the general opinion being that, whichever party won, it would be by but a narrow margin, and that if it were the Republican party, the duty would surely be maintained, while if it were the opposing party, no change would be likely to occur for some time. This caused tin to harden from week to week, and shortly before election day a very large business was done at from 20.75@20.90c. for near-by deliveries, and 21¼@21½c. for the first six months of next year.

Great was the surprise when it was found that the country had spoken so emphatically against any further legislation of the McKinley type; and as soon as the result was fairly realized, fears were entertained that the famous duty of 4c. would never become operative, and that it would be among the first to go, either through the action of the extra session that may be called next spring, or even that of the present, which might repeal an act distinctly proved to be very obnoxious to all concerned, and detrimental to the interests of the country.

As was natural, this state of affairs caused a decline, which would have reached a lower point than it did if some London speculators had not again accumulated a very large interest in the metal, and at this time found it to their interest to remain undisturbed by all the rumors that were current regarding legislative action to be taken at Washington, evidently believing that the lowering of the present prohibitive duties here would help trade in Europe. Although they took up a great deal of metal that was thrown on the market, they could not check the decline, and the market slowly came down until by the end of November it reached about 20⅛c.

All through the year the world's prices were guided solely by the question of the duty here.

The production in the East shows a slight increase, and stocks do not vary much from what they have usually been; so, taking everything into consideration, particularly the fact that exchange in silver is about 10% lower than usual, it

is but natural to assume that prices should also be correspondingly lower, or say less by about 1½@2c. than they now are.

Production in this country has made no progress at all: rather the contrary, as the mines in Lower California, which were those promising the earliest returns, have given out, and a good deal of money that has been sunk there is now probably lost. The Harney Peak mines accumulated large piles of ore on the dumps, and have lately been concentrating, but as yet no tin has actually come on the market. We doubt if the mines will ever become a factor either in this country's or the world's markets. During December the decline continued here, in spite of the fact that abroad there was considerable manipulation of the market. Prices receded early in the month until they touched 19.45c. for spot and December metal on this side, and £90 10s. for spot and futures in London; but after that, although our market was lifeless, an upward movement was inaugurated in London, and by leaps and bounds prices advanced to £93 for spot and 10@15s. less for futures. During this rise the London operators sold quite heavily, and no support coming to them from this side, the movement soon came to a natural end, and values eased off, closing in London at £91 for spot and £90 10s. for three months prompt.

The following statistics are taken from the annual metal circular of Messrs. W. T. Sargant & Sons, issued under date Jan. 11, 1893. The statistics of stocks, consumption, imports, etc., are stated in English tons of 2240 pounds.

STOCKS OF FOREIGN TIN AND QUANTITIES AFLOAT FOR ENGLAND, HOLLAND, AND AMERICA.

Calendar Years.	1892, Dec. 31.	1891, Dec. 31.	1890, Dec. 31.	1889, Dec. 31.	1888, Dec. 31.	1887, Dec. 31.	1886, Dec. 31.	1885, Dec. 31.	1884, Dec. 31.	1883, Dec. 31.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Foreign stock in London	2,776	2,155	2,524	2,290	4,231	7,128	3,110	6,561	4,885	4,788
Foreign landing	1,346	1,162	880	1,406	283	961	973	327	452	921
Australian afloat for London	2,170	2,225	1,205	2,225	2,718	3,398	1,020	1,160	1,870	1,535
Straits afloat for London	957	802	856	600	908	796	760	900	1,140	1,950
Banca on warrants in Holland	868	511	867	680	884	661	793	748	1,193	876
Billiton in Holland	326	357	277	984	671	497	730	594	1,155	1,823
Billiton afloat for Holland	1,240	1,912	1,396	1,335	1,062	1,345	1,093	990	1,154	1,154
Estimated stock in	9,683	9.124	8.005	9,520	10,757	14,786	8,479	11,280	11,849	13,047
America & quantity afloat	5,492	3,228	2.925	2,670	3,000	1,251	3,200	2,150	1,480	2,220
	15,175	12,352	10,930	12,190	13,757	16,037	11,679	13,430	13,329	15,267
Trading Co.'s reserves of unsold Banca stock in Holland	3,480	3,140	2,787	4,813	4,447	2,301	1,678	2,400	2,898	2,994
Floating for Holland	139	....	303	60	180	400	345	111	702	97

CONSUMPTION OF TIN.

	1892, Tons.	1891, Tons.	1890, Tons.	1889, Tons.	1888, Tons.	1887, Tons.	1886, Tons.	1885, Tons.	1884, Tons.	1883, Tons.
Deliveries from London after deducting all shipments to America	14,122	17,667	16,126	18,194	20,008	13,481	16,466	15,018	17,600	16,279
Deliveries from Holland after deducting exports to London and America	8,719	8.246	8,155	7,581	6,771	6,906	6,513	6,842	6,818	7,423
English consumed at home	3,158	3,834	3,872	3,830	3,286	4,088	4,330	4,350	4,200	4,236
Exports of English, minus quantity shipped to America	5,648	4,990	4,567	4,820	5,164	4,650	4,390	4,418	5,320	5,090
American consumption of all sorts	18,750	15.457	16,000	15,000	14,400	12,600	11,500	10,300	10,200	11,500
Billiton sent to other ports than Holland	2,605	1,972	1,617	1,287	2,420	1,900	1,406	1,500	1,000	1,164
Straits direct to Continent, less re-exports to America and England	5,500	3,579	3,700	3,680	1,340	1,785	1,916	611	597	......
	58,502	55,745	54,037	54,392	53,389	45,410	46.520	42,039	45,735	45,686

The London Tin Market in 1892.

The opening month was one of moderate demand, but also of moderate shipments from the Straits and particularly from Australia. Values were depressed from £91 to £89 10s. sharp cash, Straits by the sales made and by the offers from the Straits, which were as usual more pressing at this time of the year in view of the approaching Chinese new year. Consumptive demand was good, especially from the Continent and America, but speculative inquiry was of the feeblest. All the above conditions obtained also in February, though there was rather less pressure of sales by Chinese producers. The total range of variations was about 17s. 6d., £89 10s. being the highest and £88 12s. 6d. the lowest figure. The unsteadiness of the silver market affected prejudicially the tin market througout this and the previous month. A particularly strong demand from the United States, especially in the second half of March, caused an advance from £89 5s. to £89 17s. 6d., and in the first few days of April to £90 12s. 6d., notwithstanding heavy shipments from the Straits. As the American demand began to reduce London stocks, the value continued to rise rapidly and the total gain for April amounted to nearly £4 per ton, the price closing at £93 7s. 6d. after having touched £94 7s. 6d. May witnessed a still more striking development of the American demand, and it had become clear that a fair portion of it was due to a desire to lay in a big stock in view of the duty (4 cents per lb.), expected to come into force in July, 1893, under the McKinley tariff. The further depletion of London stocks, due to the heavy withdrawals for America, resulted in a rise from £93 10s. to £98 by the end of May, and £100 was reached in the first week of June. By the middle of that month this remarkable rise had attained its zenith, viz.: £10 35s. The tendency was then reversed by sales, to a large extent for American accounts. The heavy shipments to the States which had for some time been going on had raised stock in and afloat to that country to a high figure, and the approaching Presidential election influenced dealers in the States, who began to import on a less extensive scale, which resulted in a drop from £103 5s. to £99 in a single week. There was, however, a rally to £101 15s. followed by a relapse to £99 again. During July, the lack of American support, added to a falling off in the home consumption and pressure of sales by importers, resulted in a fall to £94 7d. 6s. cash and forward. The usual Dutch sale resulting very favorably (a large quantity realizing the parity of fl. 56¼ Holland), our market improved to £95 17s. 6d. Somewhat active buying at the beginning of August sent the value up to £97, but the publication at this juncture of the statistics showing an increase of nearly 1700 tons in European supplies for July tended to depress the tone, and the price went down to £93. September brought a further decline, viz., to £91 10s., due in part to shipments from the Straits, which continued on an extensive scale, and in part to sales against numerous prompts now falling due. London stocks were however small, and a better demand during the last week in September resulted in a recovery to £92 17s. 6d. Good buying early in October sent the value up to £93 7s. 6d. After an intervening drop of a few shillings, a fresh advance to £95 7s. 6d. was induced by

purchases for America and the Continent. At home, owing to the dislocation in the tin-plate industry, caused by the efforts to make the thing a success in America, consumption had fallen off considerably. The prices fluctuated during the rest of October between the above-named figure £94 2s. 6d. closing at £94. Early in November it rose to £94 17s. 6d. on pretty active buying. The defeat of the McKinley party at the polls upset the market somewhat, and induced a general desire to sell, which resulted by a single operator (after manipulations here had first caused a fall to £94 10s. and then a rise to £95) in a drop to £93 15s.

The following figures show the supply of tin in Europe and America for the 11 months ending November 30:

1892.	Tons.	Price of Spot Straits. £ s. d.	1892.	Tons.	Price of Spot Straits. £ s. d.
January 1	13,770	90 15 0	July 1	13,277	99 0 0
February 1	14,036	89 12 6	August 1	14,348	96 5 0
March 1	13,351	89 5 0	September 1	15,381	93 0 0
April 1	13,807	89 15 0	October 1	15,932	92 10 0
May 1	13,246	93 10 0	November	16,122	94 0 0
June	12,566	98 0 0			

SHIPMENTS AND DELIVERIES FOR 12 MONTHS, ENDING 31 OCTOBER.

	1892, Tons.	1891, Tons.	1890, Tons.
Straits to London	18,798	16,648	16,556
" " America	9,070	10,972	6,740
Australia to London	4,529	4,648	5,299
" " America	750	650	905
Deliveries in London	14,764	17,977	16,240

WHETSTONES AND NOVACULITE.

The records of the whetstone industry in the United States, including scythe-stones and oil-stones, are very meager. The first published item states that in 1822 a novaculite occurring in Berks County, Pennsylvania, was selling for 25c. per lb. It is probable that previous to this time the majority of whetstones used were imported from Europe. In 1823 a superior grit for scythe-stones was discovered in Grafton County, New Hampshire, and a few years later a regular scythe-stone industry was established in that section by Isaac Pike. This deposit occurs in a mica-schist formation, and has been worked continually from that time to the present. In 1827 or the following year scythe-stones were made from a quarry on the extension of this deposit, near Indian Pond, in Orford, N. H., and they have borne the trade name "Indian Pond" ever since. The Pike Manufacturing Company, Pike Station, N. H., is the present owner of the quarries which have been opened in this deposit. Their output from 1827 up to the time of the civil war was limited to a few hundred gross per annum.

In the early thirties we find that scythe-stones were made in Massachusetts, Vermont, and Pennsylvania, as well as in New Hampshire. The *Geology of Massachusetts* published in 1835 states that over 5000 dozen of whetstones were quarried annually at Smithfield in that State. The quarries in Pennsylvania were long since abandoned, and the old quarries in Vermont and Massachusetts are now owned by the Pike Manufacturing Company, which produces annually from 10,000 to 12,000 gross from the Indian Pond quarries in New Hampshire, and from 4000 to 7000 gross from the quarries in Orleans County, Vermont, which is probably two thirds of the entire production of scythe-stones in the United States. The chief other scythe-stones of commercial importance are the Western grindstone grits, quarried and manufactured in connection with the grindstone business in Cuyahoga County, Ohio, and Huron County, Michigan. The Cleveland Stone Company is the principal operator of these quarries, though a small quantity is produced by one or two other grindstone-makers.

The total output of Western stone is about 8000 gross per annum, worth about $3 per gross. The grit is of a much coarser and more brittle texture than the New England product, and is therefore unsuitable for long transportation or for setting a fine edge. The Indian Pond scythe-stones are exported in large quan-

tities to different European countries, and bring from $3.50 to $4 per gross. The Vermont scythe-stones are a little finer-grained and more compact than the Indian Pond, and sell for from $3 to $6 per gross.

The novaculite deposit at Lisbon, N. H., produces a very fine-grained, sharp-gritted, chocolate-colored whetstone, used for sharpening knives, axes, scythes, and other edged tools.

The principal oil-stones of the country are produced from the novaculite quarries in Garland County, Arkansas, and are known as the Washita and Arkansas oil-stones. This stone was first put on the market, commercially, about 1840, in which year a quantity of rough rock was shipped down the Ouachita River to New Orleans and thence to Europe, where it was cut into regular whetstones. It proved to be superior to the Turkey or other European oil-stones for sharpening or abrasive purposes, and the next year a small quantity of it was cut up and manufactured into oil-stones in St. Louis. From that time to the present the demand for it has steadily increased, and it is now recognized as the best oil-stone in the world for fine-edged tools. Previous to the war the yearly output probably did not exceed 4 or 5 car-loads of rough rock, and the price for the finished whetstone ranged from 25 to 45c. per lb.

During the war and for a few succeeding years it was very difficult to get the rough rock from Arkansas, and the price accordingly went as high as $1.25 per lb. for the finished stone. For the past 20 years the price has fluctuated from 10 to 35c. per lb. for the No. 1 quality, the extreme differences being due to the conditions of competition. At present the entire output of this rock is in the neighborhood of 20 car-loads per year of rough rock of 25,000 to 30,000 lbs. per car, worth from $300 to $500 per car, according to quality, etc. The Arkansas rock has been so difficult to quarry and manufacture that its extremely high price has kept it from coming so generally into use as its superior qualities would warrant. The demand has largely increased, however, during the last few years, and about 30 tons of rough rock are shipped annually from the quarries at Hot Springs.

The oil-stone of next commercial importance is known as Hindostan, and is quarried in Orange County, Indiana. It is a fine-grained, compact sandstone, and makes an excellent sharpening-stone for ordinary tools. It is much lower in price than the Washita, as it is more cheaply quarried and finished. It was first put on the market about 1840, and the output has gradually increased from year to year. The past few years it has averaged about 400,000 lbs. of the finished rock annually, fluctuating in selling price from 1½ to 6c. per lb., according to quality, conditions of competition, etc. There is also a coarser-grain stone quarried in Indiana, known as "shoemaker's sandstone," which is desirable for setting a coarse edge, and can be quarried and finished very cheaply. Since the introduction of improved machinery for making shoes the demand for this stone, however, has decreased largely, until to-day it is sold in comparatively small quantities, probably in the neighborhood of 150,000 lbs. annually. In 1889 and 1890 the price went as low as 1c. per lb., but at the present time it is selling at 2½c. There are several other kinds of whetstones quarried in a small way in different sections of the country, but as yet they are known only locally.

ZINC.

The production of zinc in the United States increased again in 1892, though it was less than in 1891. The steady expansion of this industry has been due to a general development in all the zinc districts of the country, especially in those of the Western States. In Illinois 1640 tons more zinc were produced in 1892 than in 1891; in Kansas and Missouri, 1574 tons; and in the Eastern and Southern States, 187 tons less.

PRODUCTION OF SPELTER IN THE UNITED STATES.*

	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
Tons of 2000 lbs	7,343	10,000	15,833	16,000	17,500	19,000	21,000	23,239	30,000
Tons of 2240 lbs	6,556	8,928	13,690	14,286	15,625	16,964	18,750	20,740	26,786
Metric tons, 2204 lbs	6,664	9,074	13,914	14,520	15,281	17,242	19,057	21,080	27,225

States.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Illinois	18,201	16,792	17,594	19,427	21,077	22,279	22,445	23,860	26,279	28,660	30,300†
Kansas	7,366	9,010	7,859	8,502	8,932	11,955	10,432	13,658	16,380	21,460	23,088
Missouri	2,500	5,730	5,230	4,677	5,870	8,660	13,465	11,077	13,530	16,205	16,161
Eastern and Southern States	5,698	5,340	7,861	8,082	6,762	7,446	9,561	10,265	11,153	13,938	13,751
Total tons of 2000 lbs.	33,765	36,872	38,544	40,688	42,641	50,340	55,903	58,860	67,342	80,262	83,300
Tons of 2240 lbs.	30,138	32,837	35,317	36,328	38,072	44,946	49,913	52,553	60,126	71,662	74,375
Metric tons of 2204 lbs.	30,642	33,375	35,585	36,921	38,696	45,682	50,731	53,414	61,111	72,836	75,594

* The figures for the years 1873 and 1875 and for 1882 to 1888, inclusive, are taken from the *Mineral Resources Report of the United States Geological Survey*. The figures for 1880 are from the Census report for the year 1880, ending May 31. Those for 1889 are from the Census report for that year. The figures for 1874 and for 1876 to 1879, inclusive, and for 1881 are estimated. The figures for the years 1890, 1891, and 1892 are from returns made to the *Engineering and Mining Journal* by each of the producers.

† In this figure, however, is included a small amount made by a new works just started in Indiana.

The chief ore supply of the Illinois smelters is the Joplin district of Kansas and Missouri, less important amounts being derived from the Wisconsin mines; while all the metal made in Kansas and Missouri is from ores originating in the southeastern corner of the former and the southwestern corner of the latter State. The past year was one of greatly increased activity in this region, and the greater part of the gain in the make of spelter can be traced directly to its mines.

Outside of the Joplin district, where a new smelter was built by the American Smelter Company, and a new departure made by the shipment to Europe of several small lots of ore and one lot of spelter, there were no important developments in the zinc industry in the United States. The Hanover district in New Mexico, whence 700 tons of ore were shipped in 1891, did nothing in 1892, the Mineral Point Zinc Company, which owns the mines, having concluded to suspend operations for the present. There are said to be large deposits of zinc ore at this place, but they are too far from market to be of much value yet.

In Colorado the American Zinc-Lead Company ran its works at Cañon City steadily through the year, and reduced (by the Bartlett process) about 12,000 tons of low-grade, complex sulphide ore, producing 2,500,000 lbs. of zinc-lead pigment, 360,000 lbs. of copper, 137,000 oz. of silver, and 120 oz. of gold. The equivalent of lead in the pigment was 625,000 lbs., and of zinc 1,125,000 lbs. About $17,000 was expended in new buildings, improvements, and machinery.

In Arkansas there was considerable activity in the zinc districts of Marion, Boone, and Searcy counties. Development work was carried on at a number of mines, and ore was shipped from the Morning Star property at Rush, Marion County, being hauled to Buffalo City, on the White River, whence it is transported by water. The output amounted to 350 tons, valued at $7200. Lack of transportation facilities has retarded the development of the zinc mines of this State.

The production of zinc in the United States can doubtless be steadily increased to meet the growth in consumption. The present capacity of the 23 spelter works in operation is in excess of 90,000 tons per annum. The deposits of zinc ore that are opened in Kansas and Missouri are of great extent and are easily worked. Hitherto they have been mined in extremely rude fashion, but within the past two or three years improved methods have been introduced, and machinery is beginning to take the place of manual labor. Probably steps will soon be begun to open the mines on a larger scale, with adequate hoisting and pumping plants, and with dressing-works, of which there are surprisingly few in the district, most of the ore being washed by hand. As it is, the Joplin district is already able to maintain a more regular output than it could a few years ago, being less subject to delays by bad weather, etc., and the smelters therefore have more certainty of a steady supply of ore.

During 1891 several lots of spelter were exported from Missouri to Europe, and hopes were entertained in the Joplin district that a new market for its ores might be opened on the other side of the Atlantic. With this object in view, Mr. A. V. Weise was sent abroad by the Southwest Missouri and Southeast Kansas Lead and Zinc-mining Association, to call the attention of the spelter producers of Europe to the resources of the Kansas-Missouri zinc region, and induce them to come into its market for ores. Last spring Mr. Weise made his report, of which the following is a brief summary:

"Last year (1891) there were several lots of spelter exported from Joplin to Europe, which had a marked effect upon prices there, and foreign miners dread the continuance and increase of such shipments. Hitherto the zinc people whom I saw—and they represent the industry in Europe—have had no idea of what zinc ores we have, how much, and of what quality.

"I was unsuccessful in my endeavors to bring them over here as buyers or investors, and for good reason. They did not need any ores; they had all they could make use of close at hand, secured by long contracts at satisfactory prices, and it is not an easy undertaking to divert to new fields a long-established trade and custom. In order to accomplish that object one must be able to show great advantages in prices and goods over the old ones.

"I could offer them a vastly better quality of ore, but as to prices I could not give them any inducements. Furthermore, their manner of doing business is

so different from ours that it naturally takes a longer trial and some palpable advantages to make them change a long-established business policy. I came to an understanding with the Vieille Montagne Company, whereby it agreed to buy blende shipped to it at Antwerp. But in the course of further negotiations it withdrew, and combined with other companies in a joint offer for a trial lot of 1000 tons, the proposed contract for which was forwarded to you for acceptance, but was declined by you as not coming up to prices obtained here."

Mr. Weise concluded that so long as the agreement between the European zinc producers for the restriction of output was maintained there would be little chance for the introduction of Missouri ore in Europe; for not only is there an abundance of ore there, but rates of freight are against mines so remote as those of Missouri.

Mr. J. R. Holibaugh of Joplin furnishes the following account of developments, ore market, etc., in this district in 1892:

"The most important zinc-producing region in the United States is the Joplin district, which extends over the southwest corner of Missouri and the southeast corner of Kansas, covering an area of about 60 miles from east to west and 30 miles from north to south. Its development is comparatively recent, as only 20 years ago but little was known concerning the value or extent of its ore deposits. The exploration of the lead mines, which were first worked, led to the opening of large bodies of zinc ore, and this region is now the most important producer of zinc ore in the United States. Great progress has recently been made by adopting improved machinery and modern methods of mining.

"The past year was a prosperous one in the mining industry in this district. The market for zinc ore opened in January at \$23.50@\$24 per ton of 2000 lbs. at the mines, and as there was but a small stock of ore on hand at that time, the output was bought promptly by the smelters. As the year advanced and the product of the mines increased, the price of ore declined to \$21.50@\$22.50 per ton. About 3000 tons of ore were shipped to Europe during the year, the amount being less than was expected, owing to the failure to arrange satisfactory transportation rates. The Empire Zinc Company also exported 50 tons of spelter to Europe. In future shipments of metal rather than of ore will be made.

"There are 5 ore-dressing plants in operation near Joplin, and 60 producing shafts, which make an output of about 250 to 300 tons of zinc ore weekly. The other camps of the region, Webb City, Galena, Carthage, and the rest, are smaller producers, but are all centers of activity. There are spelter works at Joplin, and agencies of the Illinois smelters, who are large purchasers of ore; but the most important reduction works in the region are situated at Pittsburg, Kan., where there is an ample supply of coal. During the past year a large zinc smelter has been erected at Galena, Kan., which made its first shipment of spelter in December.

The total production of the various districts in the two States during the past two years has been as follows:

Year.	Lead Ore.		Zinc Ore.		Total Value.
	Pounds.	Value.	Pounds.	Value.	
1891	28,368,408	....	274.751,859	....	\$3,840,480
1892	48.252,890	\$1,061,562	312,800.000	\$3,519,225	4,580.787

The value of output of the district in 1889 was \$2,722,500; in 1800, \$3,367,687.

In the following tables are given the United States imports and exports of zinc in its various forms:

IMPORTS OF ZINC INTO THE UNITED STATES SINCE 1867.*

Year.	Sheets, Blocks, Pigs, and Old.		Manufactures.	Total Value.	Year.	Sheets, Blocks, Pigs, and Old.		Manufactures.	Total Value.
	Quantity.	Value.	Value.			Quantity.	Value.	Value.	
	lbs.	$	$	$		lbs.	$	$	$
1867	10,895,028	568,138	1,835	569,968	1880†	10,448,681	515,678	a	575,678
1868	12,885,416	621,156	1,623	622,779	1881	8,187,993	328,212	a	328,212
1869	21,518,298	1,068,978	2,083	1,071,061	1882	30,320,128	1,240,117	a	1,240,117
1870	18,763,808	925,357	21,696	947,053	1883	8,695,898	319,890	7,5467	395,359
1871	18,805,861	917,598	26,366	943,964	1884	4,330,416	147,349	78,370	325,919
1872	22,507,191	1,116,409	58,668	1,175,077	1885	3,086,683	95,319	30,480	125,799
1873	17,962,040	1,047,105	58,813	1,103,918	1886	4,791,521	150,101	48,278	198,379
1874	9,610,405	627,983	48,304	676 287	1887	9,525,070	309,744	44,703	354,447
1875	9,354,965	546,305	26,330	572,635	1888	3,520,194	137,714	18,270	155,984
1876	5,558,682	354,390	18,427	372,817	1889	1,928,480	81,078	66,312	147,390
1877	2,608,227	145,065	2,496	147,561	1890	2,112,626	107,017	53,469	160,486
1878	2,526,804	127,134	4,892	132,026	1891	814,218	41,369	18,424	59,793
1879	2,531,016	106,341	3,374	109,718	1892	410,896	23,307	22,709	46,016

IMPORTS OF ZINC OXIDE INTO THE UNITED STATES.

Year.*	Dry.	In Oil.	Year.*	Dry.	In Oil.	Year.*	Dry.	In Oil.
	lbs.	lbs.		lbs.	lbs.		lbs.	lbs.
1886	2,526,389	79,788	1888	1,401,342	51,985	1890	2,631,458	102,298
1887	4,961,080	123,216	1889	2,686,861	66,240	1891	2,839,351	128,140

TOTAL EXPORTS OF ZINC AND ZINC ORE FROM THE UNITED STATES SINCE 1864.*

Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.	Year.	Ore and Oxide.		Plates, Sheets, Pigs, and Bars.		Manufactures.	Total Value.
	Quantity	Value.	Quantity	Value.	Value.			Quantity	Value.	Quantity	Value.	Value.	
	lbs.	$	lbs.	$	$	$		lbs.	$	lbs.	$	$	$
1864	1,658,720	116,431	95,738	12,269	....	128,700	1879	1,195,920	40,399	2,132,949	170,654	....	211,053
1865	11,129,552	114,149	184,183	22,740	....	136,889	1880 †	618,128	18,388	1,737,776	154,817	....	174,205
1866	502,320	25,091	140,798	13,290	....	38,381	1881	2,130,240	16,437	1,382,853	116,941	....	133,378
1867	411,712	32,041	312,227	30,587	....	62,628	1882	710,750	14,487	1,159,949	823,384	....	837,871
1868	934,528	74,706	1,022,699	68,214	....	142,920	1883	235,200	9,292	125,594	8,616	......	17,908
1869	....	65,411	....	....	....	65,411	1884	813,120	22,867	136,804	10,606	3,097	36,570
1870	1,712,032	81,487	110,157	10,672	....	92,159	1885	697,080	20,297	171,577	11,638	9,704	41,639
1871	1,077,552	48,292	76,380	7,823	....	56,115	1886	2,981,440	49,455	917,229	75,192	13,526	138,173
1872	412,834	20,880	62,919	5,726	....	26,606	1887	526,400	17,286	136,690	9,017	16,789	43,092
1873	26,208	2,304	73,953	4,656	....	6,960	1888	510,720	18,034	62,234	4,270	19,098	41,402
1874	285,600	20,037	43,566	3,612	....	23,649	1889	2,997,120	73,802	879,785	44,049	35,732	153,543
1875	345,296	20,659	38,090	4,245	1,000	25,904	1890	8,664,320	195,113	3,925,584	126,291	23,587	344,991
1876	1,139,936	66,259	134,542	11,651	4,333	82,243	1891	13,071,840	149,435	4,294,656	278,182	38,921	466,538
1877	719,936	34,468	1,419,922	115,122	1,118	150,708	1892	2,058,560	41,186	12,494,335	669,549	661,794	877,529
1878	1,797,600	83,831	2,545,320	216,580	567	300,978							

(a) Not stated.

* Fiscal years ending June 30 until 1883; calendar years subsequently.

† From 1880 on the figures are taken from the summary statement of imports and exports published by the Bureau of Statistics, United States Treasury Department; for the previous years the figures are from the *Mineral Resources, United States Geological Survey.*

Foreign Production of Spelter.

The world's production of spelter in 1892 amounted to about 360,000 tons of 2240 lbs., or 367,200 metric tons, of which the United States contributed about 26% and Great Britain about 8½%. The production of the continental works has changed but little in 1892 from what was reported in 1891. We have received returns from a number of the principal continental producers and from all the English works, with a single exception. The production of Great Britain in 1892 was 30,264 tons of 2240 lbs., a small increase over the output in 1891.

The accompanying tables, compiled by Messrs. Henry R. Merton & Co. of London, give the production of foreign countries from 1883 to 1891, inclusive.

PRODUCTION OF SPELTER IN AUSTRIA.*

(Compiled by Henry R. Merton & Co.)

Producer.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
Sagor	1,120	935	970	1,000	866	1,087	1,210	1,430	1,280
Cilli	1,547	1,430	1,440	1,360	1,272	1,240	1,670	1,880	1,810
Ivanec	200	....	....	....	....	....	....	....	....
Siersza-Niedzieliska	3,400	3,805	3,200	2,640	3,200	2,650	3,450	3,825	3,350
Total	6,267	6,170	5,610	5,000	5,338	4,977	6,330	7,135	6,440

PRODUCTION OF SPELTER IN SPAIN.*

Asturienne	14,671	15,341	14,847	15,305	16,028	16,140	16,785	18,240	18,360

PRODUCTION OF SPELTER IN GREAT BRITAIN.*

Vivian & Sons	7,220	7,590	8,048	7,389	4,840	6,510	6,842	6,605	7,235
English Crown Spelter Co., Ltd	5,200	4,570	3,500	3,248	4,007	4,980	4,981	4,945	5,180
Dillwyn & Co	4,660	4,894	2,967	3,015	2,843	3,904	4,540	3,930	3,580
Swansea Vale Spelter Co.	2,266	2,219	2,185	2,060	1,798	2,150	2,161	1,615	1,840
Villiers Spelter Co	2,000	2,000	1,985	1,880	1,810	1,993	2,180	1,890	2,125
Pascoe Grenfell & Sons	1,555	1,272	1,082	727	1,124	1,330	1,272	1,160	1,060
Nenthead & Tynedale Co	1,556	1,384	1,380	1,193	1,317	1,516	1,507	1,530	1,440
D. Swan & Co	1,004	780	....	....	....	....	....	....	....
Anchor Spelter Co	700†	350	....	....	....	....	....	....	....
John Lysaght, Limited	1,500	2,700	1,952	1,218	1,600	3,750	5,113	4,450	4,185
Staffordshire Knot	1,000†	1,500	700	....	....	150	1,100	350	....
Minera Mines	....	....	....	....	....	....	610	2,170	2,265
H. Kenyon & Co	500	500	500	500	500	500	500	500	500
Total	29,161	29.759	24,299	21,230	19.839	26.783	30,806	29,145	29,410

PRODUCTION OF SPELTER IN POLAND.*

	3,733	4,164	5,019	4,145	3,580	3,785†	3,026	3,620	3,760

PRODUCTION OF SPELTER IN THE RHINE DISTRICT AND BELGIUM.*

Vieille Montagne	49,265	51,744	50,687	50,790	51,517	51,670	52,016	52,865	53,820
Stolberg Co.	14,496	14,070	14,452	14,065	14,070	14,036	14,634	14,855	15,040
Austro-Belge	8,986	9,132	9,610	9,130	9,280	9,140	2,245	9,250	9,425
G. Dumont & Frères	5,800	5,800	7,072	8,000	8,368	8,759	8,863	8,350	8,370
Rhein-Nassau Co.	7,623	7,827	7,676	7,730	7,588	7,586	7,470	7,960	8,075
L. de Laminne	6,257	6,596	7,039	6,550	6,745	6,597	6,693	6,760	6,810
Escombrera Bleyberg	5,136	5,495	5,835	5,315	4,925	4,930	5,560	5,630	5,770
William Grillo	4,078	5,400	5,158	5,075	5,100	5,299	5,353	5,490	5,390
Märk, Westf., Bergw., Ver.	5,095	5,270	4,429	4,950	5,553	5,537	5,805	5,485	5,600
Nouvelle Montagne	5,392	5,030	5,079	4,995	4,975	5,032	5,090	5,350	5,550
Berzelius	4,800	5,000	5,046	4,985	4.890	4,818	4,910	5,175	5,155
Eschger Ghesquière & Co.	4,600	3,970	3,792	3,710	4,079	4,137	4,303	4,065	3,840
Société Prayon	2,363	3,906	3,879	3,725	3,905	3,906	3,956	4,100	4,130
Société de Boom	....	....	....	....	....	1,798	750†	2,295	2,720
Total	123.891	129,240	129,754	129.020	130,995	133,245	134,648	137,630	139,695

PRODUCTION OF SPELTER IN SILESIA.*

Schlesische Actien-Gesellschaft	20,495	21,609	21,750	22,730	22,680	22,917	23,675	24,840	25,245
G. von Giesche's Erben	15,418	16,716	16,782	17,505	17,600	17,594	18,206	18,550	18,700
Herzog von Ujest	10,233	10,949	14,937	15,610	15,835	15,456	16,202	16,355	16,795
Graf H. Henckel von Donnersmarck	10,238	10,040	9,680	9,355	11,565	11,193	11,392	11,670	11,230
Graefin Schaffgotsch	6.348	6,204	6,091	6,505	6,430	6,402	6,405	6,265	5,310
Graf G. Henckel von Donnersmarck	1,415	1,502	1,682	1,670	1,565	4,114	3,943	4,090	3,905
" Lazy " " "	....	310	2,165	2,450	....	....	....	....	....
(Included in Graf H. Henckel v. D.)									
H. Roth	913	1,036	1,733	1,675	1,670	1,555	1,660	1,750	1,730
W. Martulik	479	418	....	....	....	....	....	....	....
(Now included in H. Roth.)									
Wünsch	1,083	1,330	1,858	1,860	1,885	1,906	1,907	1,880	1,920
Von Tiele-Winckler	1,100	2,625	....	....	....	....	....	....	....
(Now included in Herzog v. Ujest.)									
Vereinigte Königs & Laurahütte	1,018	1,180	1,305	1,185	1,065	1,166	1,130	1,020	1,180
Graf Ballestrem	730	842	658	....	....	....	....	....	....
(Now included in Herzog v. Ujest.)									
Baron v. Horschitz'sche Erben	480	780	876	915	910	935	963	830	850
A. Wolff	430	430	....	....	....	....	....	....	....
Fiscus	25	145	106	170	170	137	170	225	215
Total	70,405	76,116	79,623	81,630	81,375	83,375	85,653	87,475	87,080

* In long tons, 2240 lbs. † Estimated.

The New York Spelter Market in 1892.

We have again to report great progress in the production of zinc in this country. What is even more astonishing is the still greater increase in consumption during the same period, due mostly to the better demand from galvanizers, and which has left the country bare of stocks. For brass and "yellow metal" purposes there may have been a slight increase, but it has not amounted to enough to account for the difference over last year, nor is the reason to be looked for in the production of sheet zinc. The sanguine expectations of producers have been surpassed, and the increased demand has maintained prices at a profitable level.

Early in the year the home market was utterly dependent on the prices in Europe, and during the first four or five months rather large contracts for metal for export were closed, partly at prices ruling here, but mostly at slightly lower rates. In all about 5000@6000 tons of spelter were exported, which greatly relieved the market; in fact, for a short time this created such a scarcity that smelters became somewhat independent. Most of the consumers, knowing of the increasing production and expecting lower prices to follow, had purchased very sparingly, and when the squeeze came they were without supplies for ordinary working purposes, and were often obliged to bid up the market against themselves, causing spot metal to command a rather large premium. This happened principally in May and June, and the situation was further aggravated by the flooding of the Missouri and Mississippi rivers, which seriously interfered with shipments.

Producers evidently realized also that the larger production meant lower prices, and therefore, while spot commanded a considerable premium, future deliveries were freely offered at more reasonable figures. Prices in England declined while those here were rising, and so brought our exports to an end; however, as there was no surplus metal here, there was no necessity for sending abroad any further quantities.

On the whole there were no great fluctuations: during January, February, and March the price ranged between 4.70c. per lb. and 4.55c. delivered at New York. The export sales were made at or a little below the lower figure, mostly in March and April, at the end of which latter month spot metal was quoted at 4.90c., owing to its scarcity, while futures were offered at 4.70c. These prices were fairly well maintained until the end of August, when a flatter tendency was to be noticed; but the heaviest decline took place in September, when it became known that the combination of European producers to regulate price and restrict and govern production had been dissolved. Some had been accumulating stocks, which they could not place, as considerable quantities of the metal were stored in the principal places of consumption. The market, when left to itself, dropped suddenly from £22 to £17 15s. per gross ton, and some weeks afterward recovered to £19. Even this price offered no inducement to ship metal from here, where prices were more than one quarter of a cent per pound above the exporting figure.

The middle of November found prices here in New York at 4.45c., and in London at £18 7s. 6d. for good ordinaries, and 2s. 6d. more for specials; but these figures were not reached again during the closing weeks of the year, a gradual decline being noticeable as the demand fell off, both here and abroad. The year closed

with prices at 4⅝c. (the highest price that can be named) for New York delivery, and £18 5s. for good ordinaries, with 2s. 6d. more for specials, in London.

The home market can now take care of the present output; but as we have good reason to think that at no distant date new mines will be opened up, prices, which are now low (we have to go back to the years 1885 and 1886 to find cheaper spelter), will tend downward rather than up. During the coming year it must be remembered, however, that the enormous development which low prices bring to the consumption will be compensated in a measure by a lessened cost of production.

AVERAGE MONTHLY PRICES OF SPELTER IN NEW YORK, IN CENTS PER POUND.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1875....	6 56	6 46	6 35	6 75	7 20	7 20	7 30	7 17.5	7 17.5	7 27.5	7 27.5	7 27.5	7 00
1876....	7 50	7 62.5	7 68.5	7 80	7 87.5	7 62.5	7 18 5	7 12.5	6 96	6 68.5	6 49.5	6 43.5	7 25
1877....	6 37.5	6 56	6 43.5	6 31	6 12.5	5 99.5	5 74.5	5 85	5 81	5 80	5 74.5	5 62.5	6 03
1878....	5 62.5	5 43.5	5 43.5	5 12.5	4 81	4 43.5	4 62.5	4 68.5	4 81	4 66	4 62.5	4 31	4 88
1879 ...	4 37.5	4 51	4 49.5	4 50	4 37.5	4 24.5	4 56	5 21	5 81	6 18.5	6 06	6 12.5	5 03.6
1880....	6 18.5	6 56	6 62.5	6 31	5 81	5 31	4 93.5	5 06	4 93.5	4 93.5	4 77.5	4 70	5 51
1881....	5 06	5 18.5	4 93.5	4 93.5	5 93.5	4 87.5	4 87.5	5 06	5 12.5	5 31	5 68.5	5 93.5	5 24.3
1882....	5 87.5	5 68.5	5 49.5	5 37.5	5 43.5	5 31	5 24.5	5 31	5 24.5	5 24.5	4 99.5	4 68.5	5 32.5
1883 ...	4 56	4 56	4 68.5	4 67.5	4 62.5	4 49.5	4 40	4 35	4 45	4 40	4 38.5	4 36	4 49.5
1884....	4 28.5	4 32 5	4 50	4 57.5	4 52.5	4 45.5	4 50	4 57	4 56	4 47.5	4 35	4 12.5	4 44.3
1885 ...	4 31	4 27.5	4 21	4 21	4 17.5	4 05	4 25	4 50	4 56	4 56	4 52.5	4 52.5	4 34.5
1886....	4 40	4 42.5	4 55	4 55	4 50	4 37.5	4 35	4 35	4 32.5	4 27.5	4 27.5	4 42.5	4 40
1887....	4 55	4 55	4 47.5	4 45	4 55	4 55	4 57.5	4 55	4 50	4 52.5	4 77.5	5 40	4 62.5
1888 ...	5 42.5	5 35	5 10	4 85	4 65	4 55	4 55	4 75	4 97.5	5 05	4 90	4 87.5	4 91
1889 ...	5 00	4 95	4 75	4 67.5	4 75	4 97.5	5 10	5 20	5 17.5	5 10	5 20	5 40	5 02.3
1890 . .	5 41	5 28	5 18.7	5 08.5	5 35	5 57.5	5 55	5 27.5	5 6	6 01.2	6 12.2	6 10.6	5 55
1891...	5 55	5 02.5	5 12.5	5 00	4 85	5 08.3	5 06.3	5 01	4 95.8	5 02	4 83	4 75	5 02
1892....	4 69	4 62	4 89	4 68	4 79	4 71	4 78	4 69	4 53	4 41	4 47	4 40	4 63

THE LONDON SPELTER MARKET IN 1892.

As anticipated at the beginning of the year's report, the new feature of regular imports of American spelter (brought into this country by a leading London firm of merchants) was a factor of considerable influence on the course of the market in 1892. These imports prevented the starvation of the market, which would have been brought about had the policy of the European combination succeeded, and by making the minimum price of the latter impossible, they contributed greatly to the downfall of the combination.

The year opened pretty firm on a better inquiry from dealers at £22 12s. 6d. for ordinaries, but the long-standing depression in the galvanized-iron trade militated against any permanent improvement, and spelter declined steadily during the month, which closed at £21 17s. 6d. Brass and yellow-metal people were also complaining greatly; and spelter, lacking the support of a good trade demand, declined still further in February, £21 5s. being eventually reached. After a momentary recovery to the extent of a few shillings, the value again eased off, touching £20 17s. 6d. early in March. Toward the end of that month, however, a scarcity of supplies for early delivery enhanced values considerably, so that by the middle of April £22 7s. 6d. was attained, or nearly equal to the best at the beginning of the year. The value remained in the neighborhood of this figure throughout May. In June, although the supply was still scanty, the poor condition of trade was much felt in this market, and, dealers pressing sales, a fresh downward movement began, which was assisted by rumors to the effect that the Silesian-

Rhenish combination had decided to reduce its minimum price from £23 to £21. Dealers grew frightened, and in some instances actually forestalled the rumored reduction by selling at £21. These rumors, though not accurate in detail, had a substratum of fact; for at the end of the month the said combination, now joined also by the Belgian producers, bound itself to hold for a minimum price of £22, London, until the end of September. The market consequently rallied to £21 15s. at the beginning of July. Consumptive demand continued, however, on a very unsatisfactory footing, and quotations remained slightly under the last-named price, although it was announced that the English producers had also joined the convention and were to hold for £22 12s. 6d. at Birmingham. August brought no trade improvement, and values receded to £20 10s. Before mid-September £20 5s. was reached. The aim of the price convention had therefore not been attained, and having no further *raison d'être,* it was broken up by the mutual consent of its members before the term fixed (Sept. 30) had arrived.

The consequence of this fiasco was the complete demoralization of the market and the total collapse of values, the price dropping in the week ending Sept. 17 from £20 2s. 6d. to £17 17s. 6d. At this low level a brisk business took place, consumers buying freely, and the price recovered to £18 5s.

While the *price* convention had thus become void, the agreement between producers for the limitation of *production* still remained in force, and will not expire until the end of 1894. The producers now agreed to a further five-per-cent reduction, to be in force till the end of the present year. This, together with the fact that Continental stocks (which had accumulated during the period of depression and were considerable at the time of the smash) were rapidly cleared off thereafter, strengthened the market.

An improvement in the yellow-metal trade, and a slow but perceptible alteration for the better in the galvanizing branch, led to good buying by consumers, which resulted in an advance to £19. Prompt spelter continues scarce; Continental sheet-zinc rollers are well employed, and the spelter market is at the present time undoubtedly in a sounder position at the level of £19 than at the much higher price ruling when the year opened.

Reverting to the opening paragraph of this report on spelter, it should be pointed out that the downward movement which set in in June rendered further purchases of American spelter impossible, and at the present moment the price at which it would pay American producers to export to England is very much above the parity of London prices. Apart from this, however, the American home demand appears so brisk that it is doubtful whether even a considerable advance in our prices would attract fresh American supplies to this country at present.

The closing prices of spelter are £18 5s. for ordinary brands and £19 to £19 5s. for specials.

The imports of sheet zinc into the United Kingdom for the past 10 years have been as follows:

Tons—1883, 20,354; 1884, 20,138; 1885, 19,663; 1886, 18,322; 1887, 19,555; 1888, 18,262; 1889, 19,261; 1890, 17,542; 1891, 20,157; 1892, 19,006.

The imports of spelter have been:

Tons—1883, 40,787; 1884, 47,147; 1885, 60,229; 1886, 54,508; 1887, 56,187; 1888, 61,045; 1889, 56,842; 1890, 56,205; 1891, 58,483; 1892, 52,793.

ASSESMENTS LEVIED BY MINING COMPANIES FROM 1887 TO 1893.

Name and Location of Company.	Levied in 1887.	Levied in 1888.	Levied in 1889.	Levied in ·890.	Levied in 1891.	Levied in 1892.	Total levied to Jan. 1, 1893.
Alliance, Utah,	....	....	30,000	....	40,000	....	150,000
Allouez, Mich..	....	80,000	40,000	40,000	....	....	1,360,000
Alpha, Nev	30,000	52,500	26,500	42,250	15,000	36,750	219,500
Alta, Nev	100,000	108,000	....	54,000	30,000	27,000	3,451,600
Anchor, Utah	70,000	105,000	15,000	....	150,000	....	340,000
Andes, Nev	50,000	50,000	25,000	25,000	30,000	25,000	?
Argenta, Nev	....	....	10,000	....	....	....	335,000
Atlantic Con	10,000	....	....	....	....	....	70,000
Baltimore, Nev	....	75,000	50,000	20,000	....	....	145,000
Belcher, Nev	52,000	....	104,000	104,000	104,000	78,000	3,160,000
Belle Isle, Nev	35,000	....	....	15,000	....	30,000	230,000
Bellevue-Idaho, Idaho	31,250	18,750	12,500	16,037	....	....	104,787
Benton Con., Nev	27,000	108,000	....	....	....	....	556,000
Best & Belcher, Nev	153,200	100,800	75,200	149,485	100,800	50,000	2,404,875
Bodie Con., Cal	100,000	100,000	75,000	50,000	....	....	675,000
Bodie Tunnel, Cal..	25,000	25,000	....	25,000	25,000	25.000	202.906
Brunswick Con., Cal	....	....	....	....	20,000	20,000	40,000
Bullion, Nev	90,000	50,000	....	25,000	50,000	100,000	2,915,000
Bulwer Con., Nev	20,000	20,000	50,000	....	15,000	....	145,000
Butte Queen, Cal	....	....	....	....	....	4,000	6,000
Caledonia Silver, Nev	15,000	15,000	....	....	150,000	....	3,185.000
California, Cal.	....	....	....	....	....	6,000	12,000
Challenge Con., Nev	....	25,000	25,000	50,000	50.000	42,500	222,500
Chollar, Nev	112,000	112,000	112,000	....	168,000	112,000	1,820,000
Cœur d'Alene, Idaho	....	25,000	....	....	....	....	25,000
Commonwealth, Nev	....	50,000	....	....	....	30,000	190.000
Comstock, Nev	15,000	....	....	....	....	....	30,000
Concord, N. C.	3,000	3,000	....	....	....	....	6,000
Concordia, Nev	....	75,000	....	....	....	....	75,000
Confidence, Nev	12,480	....	....	18,720	18,720	49,920	1,608,270
Con. California and Virginia, Nev	....	....	....	....	....	108,000	....
Con. Imperial, Nev	125,000	25,000	25,000	75,000	150,000	26,500	2,076,500
Con. New York, Nev	....	....	25,000	45,000	30,000	20,000	120.000
Con. Pacific, Nev	9,000	....	15,000	6,000	....	....	198,000
Courier, Idaho	5,000	....	....	....	....	....	10,000
Crocker, Ariz.	15,000	25,000	20,000	25,000	20,000	5.000	175.000
Crown Point, Nev	....	150,000	100,000	....	150,000	100,000	2,725,000
Del Monte, Nev	....	25,000	20,000	20,000	29,050	20.000	120.000
Derbec Blue Gravel, Cal.	....	....	....	....	....	10.000	10.000
Diana, Nev	....	10,000	....	....	....	8,000	83.000
East Best & Belcher, Nev	....	....	....	25,000	45.000	20,000	?
East Sierra Nevada, Nev	....	....	10,000	....	10,000	....	20.000
Eureka Con., Nev	....	....	50,000	....	....	....	550,000
Exchequer, Nev..	20,000	40,000	25,000	50,000	25,000	45,000	960,000
Felice, Ariz	20,000	....	....	....	....	....	20.000
Fisher, Ariz..	20,000	....	....	....	....	....	20.000
Flowery, Nev	....	20,000	....	....	....	....	130.000
Found Treasure, Nev.,	6,000	18,000	12,500	45,000	....	50,000	131.500
Gold Flat, Cal.	....	....	....	....	....	11,000	11,000
Goodyear, Mont	....	....	....	....	....	2,000	13.000
Gould & Curry, Nev	162,000	140,400	91,800	60,400	64,800	76,400	4.608.200
Grand Prize, Nev	....	25,000	120,000	25,000	....	....	785,000
Hale & Norcross, Nev	112,000	....	....	56,000	168,000	168,000	5,590,800
Hartery Con., Cal...	....	....	....	5,000	5,000	....	27,000
Hartshorn, S. Dak.	....	....	....	6,250	....	....	6.250
Hayward Group, S. Dak	....	....	....	2,000	....	....	2,000
Head Centre & Tranq., Nev	....	....	....	....	....	....	....
Heath, Idaho	20,000	5,000	....	....	....	....	25.000
Hector, Cal.	....	....	45,000	....	....	....	45,000

ASSESSMENTS LEVIED BY MINING COMPANIES FROM 1887 TO 1893.

Name and Location of Company.	Levied in 1887.	Levied in 1888.	Levied in 1889.	Levied in 1890.	Levied in 1891.	Levied in 1892.	Total levied to Jan. 1, 1893.
Himalaya, Utah	1,800	900	....	....	1,800	1,800	10,800
Holmes, Nev	....	....	....	25,000	....	....	370,000
Honorine, Utah	....	....	12,500	....	12,500	....	50,000
Huron, Mich	120,000	....	....	....	....	....	280,000
Independence, Nev	....	....	....	....	....	5,000	345,000
Iron Hill, S. Dak	....	36,250	15,000	20,625	15,000	....	169,375
Jack Rabbitt, Cal	....	....	....	....	....	15,000	100,000
John Duncan, Mich	....	....	2,000	....	....	....	4,000
Julia Con., Nev	16,500	....	....	....	11,000	....	1,474,000
Justice, Nev	31,500	52,500	....	....	26,250	42,000	3,525,000
Kearsarge, Mich	50,000	....	....	....	....	....	190,000
Kentuck Con., Nev	....	....	....	....	36,750	31,500	....
Keystone, Nev	10,000	....	....	....	....	....	240,000
Keyes, Nev	....	95,000	30,000	....	....	....	125,000
Kingman Silver, Ariz	....	....	....	....	5,000	....	5,000
King of the West, Idaho	30,000	15,000	....	....	....	....	45,000
Kossuth, Nev	10,800	10,800	....	....	....	....	433,000
Lady Washington, Nev	....	27,000	....	....	21,400	....	128,400
La Planta, Nev	....	....	3,000	....	....	....	3,000
Locomotive, Ariz	75,000	25,000	10,000	5,000	....	....	115,000
Lone Star Con., Cal	....	....	....	....	....	5,000	12,500
Manhattan, Nev	200,000	....	....	....	....	....	250,000
Martin White, Nev	....	....	25,000	50,000	50,000	50,000	1,300,000
Mayflower, Cal	150,000	175,000	35,000	....	....	....	470,000
Mexican, Nev	50,400	50,400	50,400	25,200	50,400	75,600	2,918,160
Michigan Gold, Mich	....	....	....	....	....	10,000	40,000
Mikado, Mich	9,200	6,000	....	....	....	....	15,200
Milwaukee, Mont	....	....	....	....	2,500	....	12,500
Missoula Placers, Utah	2,000	....	....	....	....	....	4,000
Modoc Chief, Idaho	....	....	....	....	....	5,000	975,000
Mollie Gibson, Colo	....	....	....	....	....	10,000	20,000
Montreal, Utah	....	....	....	....	....	750	4,500
Mono, Cal	100,000	25,000	62,500	12,500	12,500	....	772,500
Mount Terry, S. Dakota	....	....	....	750	....	....	750
Navajo, Nev	50,000	30,000	10,000	15,000	15,251	20,000	535,521
Nevada Queen, Nev	130,000	....	70,000	....	15,000	25,000	240,000
North Belle Isle, Nev	100,000	50,000	100,000	20,000	50,000	20,000	475,000
North Bonanza, Nev	15,000	15,000	10,000	....	....	....	240,000
N. Commonwealth, Nev	....	30,000	30,000	25,000	25,000	....	110,000
North Comstock, Nev	10,000	....	....	....	....	....	10,000
North Extension, Nev	25,000	....	....	....	....	....	25,000
North Gould & Curry, Nev	....	....	20,000	....	30,000	10,000	280,000
North Occidental, Nev	....	....	....	6,000	....	....	13,000
North Peer, Ariz	....	5,000	5,000	5,000	....	....	21,000
Occidental Con., Nev	25,000	45,000	50,000	75,000	25,000	50,000	270,000
Ophir, Nev	50,400	50,400	50,000	50,000	50,000	50,000	4,310,640
Origonal Keystone, Nev	....	....	....	....	....	10,000	250,000
Overman, Nev	28,800	....	57,600	28,800	79,340	126,720	4,036,400
Paradise Valley, Nev	....	25,000	....	....	....	....	57,000
Pennsylvania Con., Cal	....	....	....	....	....	2,750	36,050
Peer, Nev	....	....	20,000	10,000	15,000	20,000	200,000
Peerless, Nev	25,000	25,000	96,000	25,000	10,000	5,000	420,000
Phil Sheridan, Nev	20,000	10,000	35,000	....	....	....	65,000
Potosi, Nev	145,600	112,000	10,000	55,400	112,000	....	1,685,000
Queen Bee, S. Dak	....	....	....	3,000	....	....	3,000
Rainbow, S. Dak	....	....	....	....	....	1,250	4,250
Sampson, Utah	25,000	100,000	....	....	....	....	288,257
San Francisco, Cal	22,000	....	....	....	....	....	22,000
Savage, Nev	168,000	112,000	112,000	....	112,000	112,000	681,800
Scorpion, Nev	20,000	10,000	120,000	90,000	....	5,000	410,000
Seg, Belcher & Mides, Nev	....	25,000	50,000	80,000	50,000	25,000	255,000
Seg. Iron Hill, Dak	2,500	....	....	....	....	....	8,750
Sierra Nevada, Nev	100,000	75,000	100,000	71,910	80,000	55,000	6,356,910
Silver Hill, Nev	....	....	43,200	43,200	30,000	16,200	1,981,800
Silver King, Ariz	....	50,000	....	30,000	60,000	25,000	165,000
Siskiyou Con., Cal	....	....	....	....	8,000	7,000	15,000
Stanard, Cal	....	....	....	50,000	....	....	100,000
Summit, Cal	....	5,000	2,500	....	....	....	120,000
Taylor Plumas, Cal	4,000	6,000	....	....	10,000	....	20,000
Telegraph, Cal	....	....	....	....	....	975	3,575
Teresa, Mex	....	....	....	....	....	20,000	80,000
Tioga Con, Cal	....	10,000	....	....	....	....	295,000
Triumph, Idaho	10,000	....	....	....	....	....	20,000
Trojan, Nev	....	10,000	10,000	....	....	....	370,000
Tuscarora, Nev	....	5,000	10,000	....	....	....	15,000
Union, Utah	....	1,000	....	....	....	....	7,000
Union Con., Nev	75,000	....	75,000	50,000	80,000	50,000	2,410,000
Wall Street, Mont	....	....	....	....	....	900	1,500
Weldon, Ariz	20,000	....	10,000	10,000	10,000	5,000	55,000
Wood River, Idaho	....	....	....	....	3,000	....	3,000
N. Y. O. D., Cal	....	....	....	....	22,500	....	22,500
Yellow Jacket, Nev	....	....	60,000	....	....	156,000	5,784,000

Dividends Paid by American Mining Companies.

The following table gives the amount of dividends paid annually by a number of American mines since 1883, together with the total amount paid to date by these same mines from the date of organization. This table is not complete, and it undoubtedly contains some errors; we publish it, therefore, merely as a partial illustration of the profits of mining.

The amount paid in each of the nine years from 1884 to 1893 is indicated as far as we have information; but as some of these companies do not report their earnings regularly, it has been difficult for us to secure complete information. There are many private companies and copartnerships operating some of the richest mines which do not report their earnings at all; such, for example, are the Eureka Hill, the Bullion-Beck & Champion Mining Companies of Utah, the Diamond of Nevada, the Harqua Hala of Arizona, the Union Consolidated, Sheridan-Mendota, Smuggler (Aspen), and Compromise (Aspen) of Colorado.

It should also be noted that this table includes few of the coal-mining companies of Pennsylvania or the Central States, and few of the iron companies of Michigan, Wisconsin, and Minnesota, some of which have been extremely profitable; nor does it include any of the zinc-mining companies of the Joplin district of Missouri, which are known to be paying substantial dividends.

Although incomplete, this list shows more fully than has heretofore been shown the profits realized in mining. A list of mines which have paid some of those enormous amounts in the past is published in the *Engineering and Mining Journal;* and in the article "Gold and Silver," in another portion of this book, the profits of some of the great bonanzas are given.

DIVIDENDS PAID BY AMERICAN MINES.

1 = $1000; total, full amount.

Company.	Location of Mine.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Total Amount Paid to Date.
Adams, Silver, Lead	Colorado...	83	218	240	15	....	....	....	75	8	$634,500
(*a*) Alaska-Treadwell, Gold	Alaska	....	....	....	....	....	....	....	450	300	1,450,000
Alice, Silver, Gold	Montana...	150	125	75	....	25	25	95	75	....	975,000
Alma, Gold	Idaho... ..	....	....	....	....	....	15	....	....	....	60,000
(*b*) Amador, Gold	California..	....	....	....	....	...	....	31	....	....	31,250
Alturas, Gold	Idaho	....	...	95	....	113	....	....	....	...	262,250
American Belle, Silver, Copper	Colorado...	....	....	....	....	....	....	....	50	....	50,000
American Coal	Maryland..	....	....	....	....	....	....	....	90	90	180,000
American and Nettie, Gold	Colorado. .	....	....	....	....	....	150	....	45	30	225,000
Amy and Silversmiths	Montana...	....	....	205	43	....	....	....	....	...	247,530
Anaconda, Gold...	Colorado...	....	....		....	....	....	...	....	13	12,500
Argyle, Gold	Colorado ..	....	....	. .	....	....	....	....	....	20	20,000
Aspen, Silver	Colorado ..	....	...	..	....	80	280	200	100	100	760,000
Atlantic, Copper	Michigan ..	40	20	40	40	120	80	100	40	...	700,000
Aurora, Iron	Michigan..	....	....	....	155	....	....	....	200	100	455,000
Badger, Silver	Canada...	....	....	....	....	...	...	38	....	....	37,500
Bangkok-Cora Belle, Silver	Colorado ..	....	....	....	....	....	3	42	....	....	44,510
Bald Butte, Gold	Montana...	....	....	....	....	....	....	23	30	20	72,500
Ballarat Smuggler, Gold.	Colorado ..	....	....	....	....	....	....	....	6	...	6,000
Bannister, Silver	Montana...	....	....	....	....	....	....	24	72	6	102,000
Bassick, Silver, Gold	Colorado...	100	...	....	....	....	....	....	....	...	400,000
Bates-Hunter, Gold	Colorado...	....	....	....	....	....	....	....	68	...	67,500
Bellevue, Silver, Lead	Idaho	....	88	63	38	....	....	....	....	....	187,500
Belden, Mica	New Hamp	....	....	....	....	....	....	....	....	45	45,000
Best Friend, Silver	Colorado...	....	....	....	....	....	....	....	70	20	90,000
Big Bend, Gold...	California..	72	30	66	48	....	....	....	...	....	258,000
Bimetallic, Silver, Gold.	Montana...	...	....	....	....	....	....	290	840	200	1,400,000
Bodie Cons., Gold	California..	350	50	....	....	....	....	....	....	....	1,602,572
Boston & Montana, Cop., Silver	Montana...	....	30	180	....	400	500	625	500	..	2,075,000
Bonanza King, Silver	California..	150	10	....	....	....	....	....	....	....	185,000

DIVIDENDS PAID BY AMERICAN MINES.

1 = 1000; total, full amount.

Company.	Location of Mine.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Total Amount Paid to Date.
Brotherton, Iron	Michigan	....	....	....	....	....	....	...	....	40	$40,000
Brooklyn Lead, Lead, Silver	Utah	...	....	20	25	....	....	....	....	....	127,000
(c) Bull-Domingo, Lead, Silver	Colorado	....	....	....	....	....	....	20	29	4	53,000
Bulwer, Cons., Gold	California	....	....	....	....	....	....	....	....	15	190,000
Bunkerhill & Sullivan, S., L.	Idaho	..	....	....	....	20	....	....	....	....	150,000
Buxton	So. Dakota	....	....	....	5	....	....	....	....	20	25,000
Caledonia, Gold	Dakota	....	20	20	....	16	80	56	....	....	192,000
California, Gold	Colorado	32	....	....	....	....	....	20	....	. .	116,500
Calliope, Silver	Colorado	....	...	....	.. .	....	50	85	5	....	140,000
Calumet and Hecla, Copper	Michigan	1,300	1,700	1,000	1,000	2,000	2,000	2,000	2,000	2,000	38,850,000
Carbonate Hill, Silver, Lead	Colorado	10	....	....	....	....	..	...	....	....	80,000
(d) Carlisle, Gold	NewMexico	....	....	....	....	175	....	....	....	....	175 000
Catalpa, Silver, Lead	Colorado	30	....	....	....	....	....	....	....	....	270,000
Centennial-Eureka, S., G., L.	Utah	. ..	....	....	....	....	....	150	330	90	592,500
Central, Copper	Michigan	40	30	40	40	70	40	20	20	40	2,010,100
Champion, Gold	California	....	....	....	....	....	....	27	43	41	110,000
Clay County, Gold	Colorado	....	....	....	....	....	....	8	48	....	56,000
Cœur d'Alêne, Silver, Lead	Idaho	....	...	...	....	....	70	160	80	72	382,000
Colorado Central, Silver	Colorado	....	60	111	83	83	55	....	14	55	68,750
Colorado Fuel	Colorado	. .	....	....	....	....	178	189	252	67	685,580
Commonwealth, Silver	Nevada	....	....	....	....	....	....	20	....	....	20 000
Confidence, Silver	Nevada	....	....	....	....	175	25	....	....	...	199.680
(f) Cons., Cal. & Va., S., G.	Nevada	....	....	65	1,118	1,118	756	162	216	....	3,682,000
Consolidation Coal	Maryland	....	....	....	....	... .	....	....	....	205	205,000
Contention, Silver	Arizona	63	....	....	....	....	....	....	....	50	2,637,500
Cook's Peak, Silver, Lead	Colorado	...	....	....	....	....	....	....	55	60	114,532
Copper Bell, Silver	Montana	....	...	....	....	....	....	....	14	....	13,500
Copper Queen, Copper, Silver	Arizona	200	....	...	...	140	70	210	...	140	1,860,000
(g) Coptis, Silver	Nevada	....	....	....	....	..	10	5	60	15	90,000
Cortez, Silver	Nevada	....	....	. ..	....	....	....	173	250	95	518,000
Cosmopolitan, Silver	Utah	25	....	....	....	....	....	....	....	. ..	75,000
Crescent, Silver, Lead	Utah	....	30	30	18	....	....	..	....	....	238,000
Chrysolite, Silver, Lead	Colorado	50	....	....	....	....	....	....	....	....	1,650,000
Daly, Silver, Lead	Utah	. ..	....	....	375	....	....	450	450	..	2,212,500
(h) Deadwood-Terra, Gold	So. Dakota	....	....	....	100	....	....	....	50	100	1,150,000
Deer Creek, Silver, Gold	Idaho	....	....	....	....	10	10	....	....	....	20,000
De Lamar, Silver, Gold	Idaho	...	....	....	....	....	....	....	150	272	422,000
Derbec, Gold	California	60	40	40	20	....	30	30	20	....	260,000
Dexter, Silver	Nevada	....	....	....	....	....	....	....	50	80	130,000
Dunkin, Silver, Lead	Colorado	10	....	....	30	100	40	....	...	....	390,000
Dunstone, Gold, Silver, Lead	Montana	....	....	....	....	6	....	....	....	....	6,000
Eclipse, Lead, Silver	Colorado	....	...	....	20	....	....	....	....	....	20,000
Elkhorn, Silver, Lead	Montana	....	35	55	20	....	....	125	300	303	932,500
(i) Empire, Gold	Montana	....	....	....	71	....	....	....	....	....	70,500
Enterprise, Silver, Gold	Colorado	....	....	....	....	....	....	....	250	450	700,000
Eureka Cons., Silver, Lead	Nevada	....	....	. ..	50	88	....	38	50	13	5,004,500
Evening Star, Silver, Lead	Colorado	....	....	....	....	13	25	....	....	....	1,450,000
Father de Smet, Gold	Dakota	200	200	....	....	....	....	....	....	....	1,125,000
Franklin, Copper	Michigan	80	40	80	40	160	80	80	80	160	1,200,000
Freeland, Silver	Colorado	....	80	60	....	....	....	....	....	....	190,000
Golconda, Silver, Gold	Idaho	....	....	....	...	120	....	....	....	...	120,000
Garfield, Silver, Gold	Nevada	....	....	13	13	25	....	....	....	....	85,000
Glengarry, Silver, Gold	Montana	....	....	....	....	....	....	....	10	....	10,000
Golden Reward, Gold	Dakota	....	....	....	...	20	....	....	....	55	65,000
Gold Rock, Gold	Colorado	....	....	....	....	....	....	....	29	....	28,750
Granby, Zinc	Missouri	....	....	....	....	....	20	....	....	....	20,000
Granite, Silver, Lead	Idaho	....	....	....	..	8	20	....	....	....	28,400
Granite Mountain, Silver, Gold	Montana	....	580	1,020	2,000	1,600	2,400	2,400	1,400	520	12,120,000
Great Western, Quicksilver	California	....	....	....	....	....	....	....	25	137	162,500
Hale & Norcross, Silver, Gold	Nevada	....	....	..	....	224	...	....	....	....	1,822,000
Hecla, Cons., Silver, Lead	Montana	195	195	135	30	100	180	123	180	180	1,920.000
Helena and Frisco, Silver	Montana	....	....	....	....	....	....	79	190	20	300,000
Helena M. & R. Co.	Montana	36	138	60	....	....	....	....	....	....	197,970
Helena and Victor, Silver	Montana	....	....	....	....	....	....	....	20	....	70.000
Holmes, Silver	Nevada	....	....	75	....	...	...	....	....	....	75,000
Homestake, Gold	So. Dakota	306	525	575	300	300	188	150	150	150	4,943,750
Honorine, Silver	Utah	13	50	25	38	....	....	....	....	...	125,000
Hope, Silver	Montana	....	36	....	25	50	....	...	....	100	333,252
Horn Silver, Silver, Lead	Utah	1,200	....	....	...	....	50	200	200	200	4,550,000
Hubert, Gold	Colorado	....	....	....	....	18	5	....	...	....	247,000
Idaho, Gold	California	226	270	271	140	357	178	29	93	42	5,399,950
Ideal, Silver, Lead	Colorado	....	....	15	....	....	....	....	....	....	15,000
Illinois, Silver	NewMexico	....	....	....	25	....	20	20	....	....	65,000
Iron Hill, Silver	Dakota	....	....	112	44	....	....	...	....	....	156,250
Iron Mountain, Silver	Montana	. .	....	....	....	....	....	50	25	..	95,000
Iron Silver, Silver, Lead	Colorado	100	200	300	300	300	100	....	....	....	2,500,000
Ivanhoe	Colorado	....	....	....	....	....	10	....	....	....	10,000
Jackson, Gold, Silver	Nevada	10	15	20	....	....	5	....	5	...	55,000
Jay Gould, Gold, Silver	Montana	....	....	....	95	226	74	22	....	. .	459,000
(j) Jay Hawk, Silver, Gold	Montana	....	....	....	...	....	...	....	...	33	33,375

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1 = $1000; total, full amount.

Company.	Location of Mine.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Total Amount Paid to Date.
Jumbo, Gold	Colorado	....	....	....	33	....	....	....	....	....	$33,000
Kentuck, Silver, Gold	Nevada	21	....	3	....	....	....	....	....	....	1,350,000
Kennedy, Gold	California	....	....	....	....	....	....	....	360	80	800,000
Kearsarge, Copper	Michigan	....	....	....	....	....	....	80	....	....	80,000
Lady Franklin	NewMexico	....	....	....	100	....	....	....	....	....	100,000
Lake Superior, Iron	Michigan	....	....	....	....	....	....	....	....	400	400,000
Last Chance, Silver	Colorado	....	....	....	....	....	....	....	....	650	650,000
Leadville, Silver, Lead	Colorado	20	20	40	20	....	....	....	....	12	455,000
Lexington, Gold	Colorado	....	....	....	....	....	....	....	....	36	36,000
(k) Lexington, Silver	Montana	320	....	....	....	....	64	....	....	....	609,000
Little Chief, Silver, Lead	Colorado	40	20	....	....	....	....	20	....	....	820,000
Little Rule, Silver	Colorado	....	....	....	....	....	....	100	120	....	220,000
(l) Maid of Erin, Silver, L., C.	Colorado	....	....	....	105	409	385	454	419	140	1,910,847
Mammoth	Utah	....	....	....	20	50	130	470	320	....	990,000
Manhattan, Silver	Nevada	....	13	25	....	....	....	....	....	....	437,500
Martin White, Silver	Nevada	....	....	50	....	....	....	....	....	....	140,000
Maryland Coal	Maryland	....	....	....	....	....	....	....	84	84	168,000
Mary Murphy, Silver	Colorado	....	....	....	70	....	....	....	....	....	175,000
Maxfield, Silver, Lead	Utah	....	....	....	....	....	....	....	36	18	117,000
May Flower Gravel, Gold	California	....	....	....	....	....	....	....	75	25	100,000
May-Mazzepa, Silver, Lead	Colorado	....	....	....	....	....	....	70	110	....	180,000
Metropolitan, Iron	Michigan	....	....	....	....	....	350	250	350	....	1,637,500
Minas Prietas, Silver	Mexico	....	....	....	....	....	....	50	....	....	50,000
Minnesota, Iron	Minnesota	....	....	....	....	....	....	....	840	840	2,100,000
Mollie Gibson, Silver	Colorado	....	....	....	....	....	....	....	1,000	1,700	2,700,000
Monitor	So. Dakota	....	....	....	....	....	38	7	....	22	77,500
Mono, Gold	California	....	....	13	....	....	....	....	....	....	12,500
Montana Ltd., Gold, Silver	Montana	....	123	617	719	413	206	178	83	....	2,685,287
Morning Star, Silver Lead.	Colorado	25	25	125	75	....	....	....	50	....	925,000
Morning Star Drift, Gold	California	....	....	....	....	....	....	....	23	83	105,600
Moulton, Silver	Montana	80	150	90	60	....	....	....	....	30	440,000
Mount Diablo, Silver	Nevada	....	30	....	....	40	40	20	30	....	210,000
Mount McClellan, Silver	Colorado	....	....	....	....	....	....	....	13	....	12,540
Mount Pleasant	California	15	30	....	45	....	....	....	....	....	180,000
Napa, Quicksilver	California	....	....	....	....	....	30	40	40	70	500,000
Navajo, Silver, Gold	Nevada	50	50	....	....	....	40	....	....	....	229,950
New Guston, Silver	Colorado	....	....	....	....	100	188	170	440	124	1,210,000
New Hoover Hill, Gold	N. Carolina	....	37	....	....	....	....	....	....	....	37,200
Newton	California	....	....	....	....	....	....	....	10	....	10,000
North Banner Cons., Gold	California	....	....	....	....	....	....	....	20	....	20,000
North Belle Isle, Silver, Gold.	Nevada	....	....	....	....	200	....	....	....	....	280,000
North Commonwealth, S., G.	Nevada	....	....	....	....	....	....	....	25	....	25,000
North Star, Gold	California	....	....	....	....	150	100	....	50	50	350,000
Omaha, Gold	California	....	....	....	....	....	....	13	....	7	19,700
Ontario, Silver	Utah	900	975	900	900	900	900	1,650	900	750	13,175,000
Original, Silver, Copper	Montana	30	....	3	12	6	3	....	....	....	138,000
Oro, Gold, Silver, Lead	Colorado	....	....	....	....	....	....	95	....	....	95,000
Oro Grande, Gold	California	175	15	....	....	....	....	....	....	....	188,860
Osceola, Copper	Michigan	63	....	....	100	150	50	225	150	150	1,747,500
Pacific Coast Borax, B.	California	....	....	....	....	....	....	....	180	180	360,000
Pamlico	Nevada	....	....	....	....	21	12	....	....	12	189,080
Pandora	Montana	....	....	....	....	....	....	....	3	3	6,000
Paradise Valley, Silver	Nevada	50	....	....	10	....	....	....	....	....	160,000
Parrot, Copper, Silver	Montana	....	....	....	54	144	144	252	360	216	1,676,000
Peacock	New Mex.	....	....	50	....	....	....	....	....	....	50,000
Petro, Silver	Utah	....	....	....	....	....	....	....	18	....	17,500
Pharmacist, Gold	Colorado	....	....	....	....	....	....	....	....	24	24,000
Pittsburgh, Gold	Nevada	....	....	....	....	30	....	....	....	....	29,850
Plumas Eureka, Gold	California	....	105	53	18	70	123	....	70	25	2,643,559
Plutus, Silver	Colorado	....	....	20	....	....	....	....	....	....	20,000
Plymouth, Cons., Gold	California	600	575	300	375	80	....	....	....	....	2,280,000
Poorman, Gold	Colorado	....	....	....	....	25	15	85	....	....	125,000
Poorman, Silver	Idaho	....	....	....	....	....	....	....	....	57	56,935
(m) Quicksilver, Quicksilver	California	13	....	118	129	283	193	257	118	....	2,475,082
Quincy, Copper	Michigan	280	180	240	800	360	280	320	400	350	6,320,000
Red Cloud, Silver, Lead	Idaho	....	....	....	....	....	....	20	80	70	170,000
Reed & National, Silver, Gold.	Colorado	....	....	....	....	....	....	45	....	....	45,000
Retriever	So. Dakota	....	....	....	....	....	....	....	13	....	12,500
Rescue	New Mex.	....	....	....	....	....	....	....	....	12	12,000
Rialto, Gold	Colorado	....	....	....	....	....	....	....	32	18	50,250
Richmond, Cons., Silver. Lead.	Nevada	68	68	185	68	....	....	....	34	....	4,346,387
Robinson, Silver	Colorado	....	....	10	....	....	....	....	....	....	585,000
Rocky Fork Coal	Montana	....	....	....	....	....	....	....	100	100	200,000
Rooks, Gold	Vermont	21	30	....	....	....	....	....	....	....	61,000
Running Lode	Colorado	....	....	....	....	....	....	5	25	6	36.000
Russell, Gold	California	....	....	....	30	....	....	....	....	....	30,000
Saint Joseph, Lead	Missouri	40	66	184	90	....	....	....	....	....	1,974,000
Security, Gold	Colorado	25	25	....	....	....	....	....	....	....	56,000
Sheridan, Silver, Gold	Colorado	....	....	....	....	....	....	....	75	....	300,000
Sherwood, Zinc	Missouri	....	....	....	3	....	....	....	....	....	3,000

DIVIDENDS PAID BY AMERICAN MINES.

1 = $1000; total, full amount.

Company.	Location of Mine.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	Total Amount Paid to Date.
Sierra Bella, Silver	New Mex.	30	....	....	....	....	....	....	....	....	$30,000
Sierra Buttes, Gold	California	15	31	...	76	15	....	....	25	36	1,554,307
Sierra Nevada	Idaho	...	....	...	....	20	20	....	....	....	40,000
Silent Friend, Silver, Lead	Colorado	. .	....	75	....	....	....	....	60	....	60,000
Silver Cord, Silver, Lead, Gold	Colorado	....	....	....	....	....	45	...	....	....	265,000
Silver King, Silver	Arizona	50	200	225	175	....	...	....	....	....	1,950,000
Silver Mining of Lake Valley	New Mex.	....	....	....	....	25	25	180	80	....	310,000
Silverton, Silver	Colorado	32	....	48	....	...	....	....	....	....	80,000
Small Hopes, Silver	Colorado	800	888	775	600	....	25	25	...	38	3,200,000
Standard, Gold	California	75	....	....	20	50	....	....	10	40	3,645,000
Syndicate	California	60	12	....	....	....	....	....	....	....	72,000
Tamarack, Copper	Michigan	....	....	....	....	640	440	590	800	600	3,070,000
Teal and Poe, Silver, Lead	New Mex.	.. .	....	...	....	....	....	....	9	....	9,000
United Verde, Copper, Silver	Arizona	60	....	....	....	....	....	30	....	30	207,500
Utah	Utah	....	....	....	....	....	...	....	....	15	15,000
Valencia, Mica	New Hamp	19	19	4	....	....	...	....	....	....	41,250
Viola Limited, Silver, Lead	Idaho	....	....	38	38	94	....	....	....	....	337,500
Ward, Cons., Silver	Colorado	....	....	....	....	....	20	....	...	...	20,000
Webb City, Zinc	Missouri	....	....	....	....	....	4	....	....	....	4,400
Whale	Colorado	....	....	....	....	....	....	....	5	....	5,000
Woodside, Silver	Utah	. ..	....	....	....	...	25	. ..	....	....	25,000
W. I. O. D., Gold	California	....	....	....	....	....	....	....	6	36	42,000
(n) Yankee Girl, Silver	Colorado	....	....	300	187	....	....	125	260	....	1,665,000
Yosemite, Silver	Utah	....	....	....	. ..	....	....	....	....	5	5,000
Young America, Gold	California	....	....	165	....	10	...	....	...	....	175,000

(*G*) Gold; (*S*) Silver; (*L*) Lead; (*I*) Iron; (*C*) Copper; (*Q*) Quicksilver; (*B*) Borax; (*Z*) Zinc; (*M*) Mica.

(*a*) Formerly the Alaska Mining and Milling Company, reorganized in 1891 as the Alaska-Treadwell Gold-mining Company; the dividends credited for 1891 and 1892 are the payments of the latter company. The Alaska Mining and Milling Company paid $700,000 previously.

(*b*) Amador Gold-mining Company, Limited.

(*c*) Bull-Domingo Mining and Leasing Company, which acquired possession of the Bull-Domingo mine from the Phœnix Lead Company in 1890 under terms of a lease.

(*d*) Reconstructed into the Golden Leaf, Limited, of Montana.

(*e*) Cœur d'Alêne Silver-Lead Mining Company, operating the Poorman mine in the Cœur d'Alêne district, Idaho.

(*f*) Previous to the consolidation in August, 1884, the California had paid $31,320,000 in dividends and the Consolidated Virginia $42,390,000.

(*g*) Formerly the Young America South Mining Company, reorganized as the Coptis in 1891.

(*h*) Previous to consolidation, the Deadwood paid $275,000 and the Terra $75,000.

(*i*) Reconstructed as the Golden Leaf, Limited.

(*j*) Jay Hawk and Lone Pine Consolidated Mining Company, Limited.

(*k*) Société Anonyme des Mines de Lexington.

(*l*) Maid of Erin Silver Mines, Limited, formerly Henriette and Maid Consolidated Mining Company. The dividends for 1887, 1888, 1889, and 1890 were paid by the old company, and those for 1891 and 1892 by the new company.

(*m*) Including dividends paid on preferred stock and common stock.

(*n*) Yankee Girl Silver Mines, Limited, formerly Yankee Girl Mining Company. The above statement ncludes the payments by both the old and new companies.

(*o*) Enterprise Mining Company, of Rico, Colo.; there is also an Enterprise Mining Company in Aspen and one in Leadville.

(*p*) Poorman Mines, Limited, operating the Poorman Mine at Silver City, Idaho, which paid large dividends in 1865 and 1866.

Baltimore Mining Stock Market.

The mining-stock market in Baltimore for the year 1892 is worthy of mention only for the unprecedented dullness that prevailed. Some of the fancy stocks have been cut from the Stock Exchange list, while others have sunk into insignificance, and are entirely ignored at the nominal quotations of a few cents per share. Among the North Carolina stocks, which at one time dominated this market, Silver Valley alone had a fair record of transactions, and its spasmodic bursts of activity furnished occasional opportunities to those who still like to take a "flier" in a "miner." The George's Creek Coal Company yielded a few dollars during the year, and is now selling around $108, with a 3% dividend soon to come off. Consolidation Coal held its own, ruling from $27 to $29, with but few sales recorded.

FLUCTUATIONS IN PRICES OF MINING STOCKS AT BALTIMORE DURING 1892.

Company.	Par Value.	Opening.		Highest and Lowest during the Year.				Closing.	
				Bid.		Asked.			
		Bid.	Asked.	Highest.	Lowest.	Highest.	Lowest.	Bid.	Asked.
Atlantic Coal	....	$1.00	$1.00	$1.00	$1.00	$1.00	$ .80	$1.00	$ .80
Baltimore and North Carolina	....	.05	.25	.10	.01	.25	.04	....	....
Big Vein Coal	....	1.01	1.30	1.01	1.01	1.30	1.00	1.00	1.00
Conrad Hill	....	.01	.10	.27	.01	.29½	.10	.01	.10
Consolidated Coal	....	.25	.30	.27	.25	.30	.21	.29	.29
Diamond Tunnel	....	.05	.30	.08	.05	1.10	.30	.08	.15
George's Creek	....	1.08	1.09	1.08	.15	1.09	.25	1.05	1.09
Lake Chrome	....	.05	.15	.15	.04	.25	.15	.04	.15
Silver Valley	....	.50	.60	.55	.50	.70	.60	.50	.65

Boston Mining Stock Market.

The past year was an exceptionally dull one in the market for copper shares, and prices ruled lower generally than for many previous years. The cause is doubtless to be found in the fact that ingot copper was so cheap that many of the companies found it impossible to produce copper at a profit, and the business has been concentrated in the hands of the larger companies, which by their superior advantages have been enabled to earn dividends, even at the prevailing low rates.

The favorite Calumet and Hecla mine, with its immense production of over 4000 tons of mineral per month, pays to its stockholders $20 per share annually in dividends. Its stock is very closely held and rarely comes into the market except in small lots, or to settle up an estate. Its highest quoted price during the past year was $300 per share, and the lowest $253.

Tamarack stock is also sought by investors, and has paid its holders $16 per annum for several years, but in 1892 only $12 was paid. Its market price in March last was $175 per share, which proved the highest, while the lowest was in September, viz., $147.

The Quincy mine is an old-time favorite with Boston capitalists. Some time since, by reason of alleged violation of the rules of the Exchange, dealings in it were prohibited, and it was stricken from the list. Recently, however, it has been readmitted, and shows by its market price that it has not lost prestige in the public favor. The stock sold at about $100 per share early in the year, but later $145 was quoted. It paid two dividends, one of $4 and one of $2 per share.

Osceola is another stock which is largely held for its dividends. It was subject to the varied phases of the market in 1892, and at one time sold at $23, but of late it has improved. Sales were made in December at $38 per share. The mine paid its stockholders $3 per share in 1892.

The Franklin, which was supposed to be nearly or quite exhausted, still lives, and made a good record in 1892, paying its stockholders two dividends of $2 per share each. In February the stock sold at $11 per share ex-dividend, but in March at $16½. This was the highest price for the year, and toward the close it sold at about $14.

Atlantic did not make much of a showing in 1892, and owing to the prevailing low price of copper it paid but one dividend, $1 per share. The stock sold in March at $13⅝, but in June it had declined to $9, and at the close sold at about $10 per share.

Kearsarge and Centennial, Lake Superior mines in process of development, have failed, so far, to meet the expectations of their owners. Of the two the Kearsarge is the most promising. Its market price ranged from $15⅝ to $10. Centennial sold in March at $13⅝, but in September, owing to the discouraging outlook, dropped to $5 per share, and closed at the end of December at $7.75.

Tamarack, Jr., was listed on the Exchange in June and sold at $46½ per share; previous to this month sales were made privately at much higher figures. It was expected that the mine would prove as valuable a producer as its namesake, but it has been disappointing. Its stock sold in September at $16 per share, and closed in December at $21.00.

In the still more speculative stocks there was but little activity. A transaction now and then has been recorded, but nothing to indicate any special interest in them. An advance in ingot copper to 15 or 16c. per lb. would doubtless bring them again to the surface, but of that there is no apparent probability at present. There were sales of Allouez at 75c.@$1¾, Arnold 65c.@$1½, National 75c.@$1½, Ridge 50c.@$1, Mesnard 50c.@52½c., Humboldt 30c., Bonanza 45c. in January and 25c. in October, and Tecumseh at 75c. Copper Falls is a small producer, the stock of which is nearly all in the hands of one party and is rarely quoted on the Exchange. A few sales were made in November at $7⅝@$7½, which were the only ones for the year. Wolverine, which has some promise of being a mine in the future, sold early in the year at $4 per share, but subsequently declined to $1¼ and closed at $1¾@$2. Santa Fé, which sold at $2½ per share about two years ago, now sells at 8c.

Boston and Montana and Butte and Boston (commonly called the Montana group) played an important part in the dealings at the Exchange in 1892. The former has heretofore paid dividends, and in 1891 sold as high as $50 per share. The highest price touched in 1892 was $46½, in May, and the lowest $30, in September, sales aggregating about 230,000 shares for the year. Its last dividend was

paid in November, 1891, and there is some doubt of its ability, owing to the large outlay required for the plant, to pay another for some time to come. Butte and Boston, under the same management, is thought to have a great future. A large amount of money has been spent in development work and machinery, and it will eventually be able to make good returns for the investment. Its highest market price in 1892 was in January, when it sold at $17½, and its lowest, in July, was $7.00; later sales were at $13. The year closed with a more hopeful outlook.

The demand and uses for copper are steadily on the increase, and, with fairly remunerative prices for the metal, many of the mines which are now idle will be encouraged to resume work and gladden the hearts of the stockholders with prospective dividends.

FLUCTUATION OF PRICES OF MINING STOCKS IN BOSTON DURING 1892.

Name and Location of Company.	Par Value.	Jan.		Feb.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Allouez, Mich	$25	1.75	1.00	1.25	1.00	1.75	1.00	1.50	.75	1.00	.75	1.13	1.00
Arnold, Mich	25	.65	....	....	....	1.25	.70	1.07	1.00	1.13	1.00	....	....
Atlantic, Mich	25	12.25	9.75	9.75	9.00	13.50	9.50	12.50	11.00	11.50	11.00	11.50	10.00
Bonanza C. & M	10	....	....	.42½	....	.55	.45	.52½	.47½	.40	....	4.0	..
Bost. & Mont., Mont	25	40.87	33.00	33.50	31.00	36.00	32.63	44.88	39.25	46.25	41.25	45.25	39.63
Breece, Colo	25	....	....	....	....	.40	.30	.42½	.40	....	....	....	....
Butte & Boston, Mont.	25	17.75	14.50	15.00	13.50	15.50	13.75	15.50	10.50	11.75	11.38	13.50	11.75
Cal. & Hecla, Mich	25	267.00	258.00	266.00	253.00	280.00	265.50	280.00	265.00	276.00	266.00	274.00	268.00
Catalpa, Colo	10	....	....	.22½	.15	.30	.20	.27½	.20	.30	.20	....	....
Centennial, Mich.	25	11.00	8.25	9.50	6.50	13.63	8.25	12.00	9.75	12.38	10.00	11.50	9.63
Cœur d'Alêne, Idaho	10	1.05	....	....	....	....	....	.70	....	....	....	....	....
Crescent, Colo	10	.12	....	.12	....	.17½	.10	.12½	.10	.10	....	.08	....
Dunkin, Colo	25	.40	....	....	....	.40	.37½	.40	.37½	.30	....	....	....
Franklin, Mich	25	16.00	11.00	13.00	11.00	16.50	12.50	15.75	14.25	15.25	14.50	15.25	14.75
Kearsarge, Mich	25	13.13	10.00	11.75	10.00	15.63	10.00	14.63	12.25	13.75	13.00	13.50	11.25
Lake Superior Iron	...	62.50	....	....	....	....	....	....	....	....	....	....	....
Mesnard, Mich	25	....	....	....	....	....	....	....	....	.53	....	....	....
Napa, Cal	2	4.88	4.63	5.13	5.00	5.75	5.00	6.00	5.50	6.25	6.13	....	....
National, Mich	25	1.50	1.00	1.00	....	2.00	1.00	.50	....	....	....	....	....
Osceola, Mich	25	30.50	25.00	28.50	23.00	35.00	25.25	33.75	30.00	33.25	31.25	32.75	31.00
Quincy, Mich	25	....	....	....	....	....	....	....	....	....	....	....	....
Ridge, Mich	25	.50	....	....	....	1.00	.75	....	....	....	....	....	....
Santa Fé, N. M	10	.30	.27½	.27½	.22½	.45	.22½	.42½	.37½	.35	.18	.20	.13
Tamarack, Mich	25	162.00	155.00	155.00	147.00	175.00	155.00	175.00	162.00	170.00	162.00	166.00	164.00
Tamarack, Jr., Mich	...	....	....	....	....	....	....	....	....	....	....	....	....
Tecumseh, Mich	25	....	....	....	....	.75	....	....	....	....	....	....	....
Wolverine, Mich	25	4.00	3.50	....	....	3.50	1.75	2.50	....	2.00	....	2.00	1.25

Name and Location of Company.	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Sales.
	H.	L.	H.	L	H.	L.	H.	L.	H.	L.	H.	L.	
Allouez, Mich	.91	.75	1.00	....	1.00	.90	1.25	.80	1.00	....	1.00	.75	21,865
Arnold, Mich	...	....	1.25	1.10	1.50	1.13	1.75	1.25	1.75	1.00	1.25	1.13	8,560
Atlantic, Mich	10.25	9.00	10.25	9.50	11.00	9.50	11.75	9.25	10.75	10.25	11.00	9.50	12,497
Bonanza C. & M	...	..	.30	...	....	....	.28	.25	...	....	.27½	.25	7,750
Bost. & Mont., Mont	40.00	33.50	37.50	35.50	37.00	30.00	37.00	30.00	35.00	30.00	36.50	31.25	227,129
Breece, Colo	....	....	...	....	....	..	...	...	....	...	....	....	2,900
Butte & Boston, Mont.	12.50	7.00	9.88	9.00	9.50	7.50	10.00	8.00	12.00	8.88	12.50	.10	108,746
Cal. & Hecla, Mich	276.00	270.00	300.00	280.00	295.00	278.00	295.00	277.00	295.00	287.00	297.00	290.00	3,991
Catalpa, Colo	....	....	.15	...	.20	...	.16	.15	.15	....	.19	....	11,010
Centennial, Mich	10.00	8.00	8.75	7.00	7.75	5.00	11.00	5.50	9.50	7.50	8.00	7.00	73,658
Cœur d'Alêne, Idaho	....	....	.70	....	.79	....	....	....	...	....	....	....	3,500
Crescent, Colo	.08	...	....	...	....	....	....	....	....	....	....	...	12,825
Dunkin, Colo	.25	....	....	....	...	....	....	....	...	...	.17½	.15	3,300
Franklin, Mich	....	....	12.50	12.13	13.00	12.00	15.00	13.00	14.00	11.75	14.50	12.50	27,497
Kearsarge, Mich	12.50	11.88	11.50	11.00	11.50	10.00	12.25	10.00	12.75	11.50	13.63	11.50	23,813
Lake Superior Iron	....	...	43.00	40.00	40.00	....	....	....	...	....	30.00	25.00	1,615
Mesnard, Mich	...	...	....	....	....	....	.50	....	.50	....	....	....	875
Napa, Cal	6.13	6.00	...	....	6.13	5.50	5.88	5.63	6.25	5.75	6.00	5.75	5,750
National, Mich	..	....	...		.75	....	...	....	....	....	....	....	2,335
Osceola, Mich	33.00	23.75	32.50	31.00	32.50	29.00	36.00	29.25	36.00	33.00	38.00	34.25	60,593
Quincy, Mich	....	....	....	....	....	...	....	....	139.50	126.00	145.50	143.00	1,510
Ridge, Mich	....	....	....	....	...	..	....	...	....	....	....	....	700
Santa Fé, N. M	.13	.10	.15	.10	.13	.10	.11	.10	.08	....	....	...	114,336
Tamarack, Mich	165.00	155.00	170.00	155.00	160.00	151.00	162.00	148.00	165.00	155.00	162.00	154.00	10,170
Tamarack, Jr., Mich	38.00	33.50	28.00	19.50	25.00	19.00	24.00	16.00	26.50	21.00	26.00	19.00	4,290
Tecumseh, Mich	....	...	...	..	...	....	...	....	...	....	....	....	100
Wolverine, Mich	2.00	....	...	....	2.00	....	2.75	1.50	2.00	....	1.88	1.25	8,680
Total sales	...	....	....	....	....	....	....	....	....	....	..	....	759,995

Denver Mining Stock Market.

Trading in the Denver stock market in the early part of 1892 was active, and prices were held firmly for a period. The indebtedness of the Stock Exchange, as well as the impossibility of maintaining fictitious values of comparatively worthless stocks, resulted in a slump in the market in June, and a lessening of business, from which it has not yet fully recovered. As usual, the greater portion of the trading was confined to sales of the minor stocks, which had every appearance of being washed. Values throughout the year closed lower than the opening, some quotations being mere fractions of those at the early part of the year. Some of the stocks which suffered appreciable declines were those which it has been stated have paid their dividends without earning them, and which were placed to a large extent in Eastern States on the basis of dividend-paying mines. An earnest effort to purify the Exchange is now being made, as it is recognized that without public confidence there can be but little business.

FLUCTUATIONS IN PRICES OF MINING STOCKS IN DENVER DURING 1892.

Stocks.	High.	Low.	Sales.	Stocks.	High.	Low.	Sales.
Anaconda, gold	$1.25	$0.07	173,800	Gold Rock	.60	.04	95,700
Alleghany	.10	.04	42,300	Ironclad	.23	.05	529,900
Amity	.04	.01	642,700	Justice	.25	.02	529,000
Argonaut	.30	.10	4,200	Leavenworth	.06	.01½	5,000
Ballarat	.23	.05	26,500	Lexington	.42	.16	35,700
Bangkok-Cora B.	.08	.01½	219,300	Little Rule	.90	.04	1,600
Bates-Hunter	.60	.03	9,400	May-Mazeppa	1.10	.05	19,900
Big Indian	.08	.02	600	Matchless	3.00	2.90	300
Big Six	.07	.01	19,400	Morning Glim	.45	.20	34,500
Brownlow	.12	.02	363,200	Park Consolidated	.08	.04	10.000
Calliope	.14	.04	18,200	Paul Gold	.11	.01	58,500
Claudia J.	.05¼	.00¾	894,200	Pay Rock	.05	.01½	117,400
Camp Bird	.15	.04	36,200	Puzzler	.20	.02¾	140,400
Century	.12	.02	118,000	Reed-National	.25	.05	......
Clay County	1.10	.01	41,600	Sutton	.20	.15	17,500
Cash	.35	.10	1,100	John Jay	.01	.01	12,600
Columbian	.05	.02	..	Rialto	1.14	.90	6,600
Diamond B.	.04	.01½	280,500	Potosi	.01½	.01	10,000
Denver Gas and Oil	.20	.01½	670,100	Whale	.07	.03	1,800
Emmons	.50	.35	387,700	Running Lode	.33	.10	8,900
Gettysburg	.33	.02	11,600				
Golden Treasure	.75	.05	23,500	Total for the year			5,719,400

* Buyer 30. † Buyer 60.

London Mining Stock Market.

Almost all the mining stocks on the London market suffered a decline during the year. As the product of these mines was mainly silver, it is natural that during the decline in the value of that metal the expectations of dividends were lessened; and this, no doubt, influenced sales on the part of stockholders and caused weakness in the market. One of the striking declines of the year was that

of the stock of the Montana Company, Limited, which fell from 11s. per share to 2s. 3d. after the reconstruction of the company had been effected. The prospects of this company are not considered bright enough to prophesy a higher value for its stock. De Lamar paid dividends with regularity throughout the year and remained fairly steady, although, unlike the Elkhorn, which is under the same management, it did not increase in value. Golden Feather and Golden Gate, California, remained steady. Mammoth Gold of Arizona fell off somewhat, although this company is supposed to be earning a profit which is devoted to the purchase of new property. Maid of Erin, New Guston, and Yankee Girl, three of the formerly favorite Colorado stocks, suffered marked declines; the management of the Maid of Erin is now in American hands, and it is thought that this not only will save a large income tax, but will affect various economies. American Belle, Yankee Girl, and New Guston are considered to have a good future before them, particularly as the completion of the new copper smelter at Durango will render available a large supply of low-grade cupriferous ores which hitherto have been unworked. Dickens-Custer, on receipt of very unfavorable reports from the mine, confirmed by an utter absence of profit in the working, fell to 6d. a share; it is not probable in the present condition of these properties that it can earn a profit. During the year few new companies have been offered, and there has been the greatest difficulty in placing them; the attention of investors has been diverted toward South African stocks, which in many instances have advanced considerably in value.

FLUCTUATIONS IN PRICES OF MINING STOCKS AT LONDON IN 1892.

Name and Location of Company.	Par Value.		Opening.			Highest and Lowest During Year.						Closing.		
	£	s.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Amador, Cal	....			4			4			3	6		1	3
American Belle, Colo	....			7	6		7	6		5			3	
Canadian Phosphate, Canada	....			10			10			5			10	
Colorado United, Colo		19		2	6		2	6		1	6		2	6
Consolidated Esmeralda, Nev	1	9		1			1				6			
De Lamar, Idaho	....		1	4		1	4		1	2		1	1	3
Dickens-Custer, Idaho	1			10			10	6			6			6
Elkhorn, Mont	....		1	0	6	1	12	6	1	0	6	1	12	6
East Arevalo, Idaho	....		....			....			....			....		
Elmore, Idaho	....				9			9			3			6
Garfield, Utah	1			1	6		1	6		1			1	
Golden Feather	....			8			8			7	6		8	
Golden Gate, Cal	....			4			4			3	6		3	3
Golden Leaf, Mont	....			5	3		5	3		4	9		1	6
Jay Hawk, Mont	....			9	6		9	6		8	6		9	
Kohinoor, Colo	1			1	3		1	3			9		1	
La Luz, Mex	....			1	6		1	9		1			1	9
La Valera, Mex	....			2	9		2	9		2	3		2	6
Maid of Erin, Colo	....		1	19		1	10			17	6		17	6
Mammoth Gold, Ariz	....			2	3		2	3		1	9		1	9
Montana Limited, Mont	1			11			11			10	6		2	3
New Californian, Colo	1			2	6		2	6		2			2	
New Consolidated	1			1			1				6			6
New Eberhardt, Nev	....				9			9			6			6
New Gold Hill, N. C	....			1	3		1	3			9		1	
New Hoover Hill, N. C		10			9		2	6			3		2	6
New Guston, Colo	....		3	5		3	5			11	3		11	3
New Viola, Idaho	....			1	6		1	6		1			1	
Old Lout, Colo	....			7	6		7	6		2	6		2	
Parker Gold, N. C	....			1	3		1	3			9			4½
Pittsburg Consolidated, Nev	1			2			2			1	6		2	6
Richmond Consolidated, Nev	5			15			15			10			10	
Ruby & Dunderburg, Nev	1				6			6			3		5	
San Christian, N. C	....			1	3		1	3			9	....		
Sierra Buttes, Cal	2			7	6		7	6		6	3		7	6
Sierra Butte-Plum-Eureka, Cal	....			12	6		12	6		10			12	6
United Mexican, Mexico	10			3	6		3	9		2	6		3	9
West Argentine, Colo	....				9			9			3			3
Yankee Girl, Colo	....			17	6		17	6		16	6		5	

Lake Superior Mining Stocks.

SPECIAL REPORT BY A. M. HELMER, MILWAUKEE, WIS.

Since my last annual report there has been so little trading in iron stocks that it is almost impossible to give quotations. There is absolutely no market for non-dividend payers, and the dividend payers are little sought for and few sales have been recorded. The Aragon mine was sold late in the season by Angus Smith of Milwaukee and his associates to the Schlesinger syndicate. This is a good property, and it is understood that the new owners are to work it to its full capacity. The Brotherton mine, which shipped about 100,000 tons of ore in 1892, has recently declared a dividend of 50c. a share. The Mesaba properties have lately attracted the most attention, owing largely to the phenomenal position and lay of the ore beds of that region, which are nearly flat and very close to the surface. The total shipments from the Lake Superior region in 1892, including rail shipments, were about 8,800,000 tons. The following quotations of stock, compared with those of 1891, are given, so far as there were transactions:

GOGEBIC RANGE.

Mine	Capital Stock.	Par Value.	Quotations. Dec. 1891.	Quotations. Dec. 1892.	Mine.	Capital Stock.	Par Value.	Quotations. Dec. 1891.	Quotations. Dec. 1892.
Aurora	$2,500,000	$25.00	$10.75	$9.50	Northern Chief	$3,000,000	$100.00	$25.00	....
Ashland	1,000,000	25.00	55.00	40.00	North Pabst	1,000,000	25.00	2.00	....
Anvil	200,000	5.00	3.50	2.00	Odanah	500,000	25.00	12.50	$10.00
Brotherton	2,000,000	25.00	2.50	2.60	Pence	1,000,000	25.00	1.25	....
Germania	1,000,000	25 00	7.00	....	Ruby	1,000,000	25.00	....	....
Gogebic	5,000,000	25.00	.25	.15	Ryan	1,000,000	25.00	.35	....
Ironton	1,000,000	25.00	1.00	.....	Superior	250,000	10.00	9.00	....
Iron Belt	5,000,000	25.00	2.00	2.00	Section 33	500.000	25 00	9.50	....
Metropolitan	2,000,000	25.00	65.00	65.00	Wisconsin	2,500,000	25.00	.50	....
Montreal	500,000	25.00	10.50	.....	....	....	....	....	....

MARQUETTE RANGE.

American	$1,000,000	$25.00	.....	.....	Lake Superior	$1,500,000	$25.00	$65.00	....
Cambria	500,000	25.00	$12.50	$50.00	Milwaukee	....	25.00	4.50	....
Champion	500,000	25.00	80.00	15.00	Pitts.& Lake Ang.	500.000	25.00	145.00	....
Cleveland	2,500,000	25.00	15.50	......	Republic	2,500,000	25.00	27.00	....
East New York	6,000	25.00	2.00	....	River Side	40,000	25.00	2.00	....
Jackson	300,000	25.00	105.00	.....	....	....	....	....	....

MENOMINEE RANGE.

Chapin	$2,100,000	$25.00	....	....	Mastodon	....	$25.00	......	....
Commonwealth	500,000	25.00	$10.50	....	Sheridan	$20,000	25.00	$4 00	....
Monitor	1,000,000	25.00	.50	....	....	....	....	....	....

VERMILION RANGE.

Chandler	$1,000,000	$25.00	$40.00	$45.00	Minn. Iron Co.	$14,000,000	$100.00	$83.00	....
Chicago & Minn. Ore Co.	2,000,000	100.00	105.00	....	Vermilion P. & I. L. Co	1,500,000	25.00	2.00	....

MESABA RANGE.

			Present Nominal Value.				Present Nominal Value.
Biwabik	$2,000,000	$100.00	$31.00	Mesaba Mountain	$3,000,000	$100.00	$21.00
Cincinnati	3,000,000	25.00	2.20	Lake Superior	5,000,000	25.00	2.50
Great Northern	3,500,000	100.00	7.00	....	....	....	....

New York Stock Market.

The past year in the New York mining stock market was the dullest in the history of the Consolidated Stock and Petroleum Exchange, where the greater part of the business is done. The total number of shares sold in 1892 was only 1,527,371, against 2,522,660 in 1891, 3,925,926 in 1890, 4,114,480 in 1889, and 11,689,388 in 1888. In Denver business has dwindled to a small figure. The mining exchange there, in the language of the West, "started up with a boom and a hurrah;" a magnificent building was erected for it, but it has been unable to retain it. The depression there is due partly to the continued low price of silver, and partly to the fact that the public engages less in stock speculation and more in legitimate mining enterprises than formerly. In San Francisco there was a similar state of affairs, due, however, to the very natural lack of confidence in the management of the various mining companies of the Comstock lode, the dishonesty of which has been so thoroughly exposed by the *Engineering and Mining Journal.*

In the New York market the Comstock stocks show, as clearly as any other group, how speculation in mining shares has declined. There were, as usual, a few "boomlets," but these attempts to advance prices proved futile, and no excitement ensued. Of late, the most important event was the news that fire had broken out anew in the Consolidated California and Virginia simultaneously with the levying of an assessment of 50c. per share, and suspicions naturally were aroused by the coincidence. It is impossible to say how many shares of Comstock stocks actually changed hands during 1892 at the Consolidated Stock and Petroleum Exchange. The official reports cannot be taken as trustworthy, for many of the sales recorded are not *bona-fide* transactions. The range of prices as quoted is given in the table at the end of this article.

So far as actual trading is concerned, no feature of interest developed in the Tuscarora stocks. They were almost wholly neglected by a public which very sensibly declines to have anything to do with a group of mines the management of which is under a cloud of suspicion similar to that which attaches to the Comstock "ring." All the mines of this group are now closed down except the Navajo, at which only a small force is employed. Generally speaking, these stocks declined steadily, especially during the latter part of the year. A glance at our table of assessments and dividends will show the record of the Tuscarora mining companies during 1892.

Of the other Nevada stocks nothing of interest can be reported. There were a few sales of Eureka, Martin White, and Mount Diablo, but the last named was not dealt in after February.

Of the California stocks the Bodies, with the exception of Standard Consolidated, have been among the least popular. The glory of Bodie has departed, probably never to return. Standard Consolidated was an exception. Good management enabled it to disburse $40,000 in dividends during 1892, and in addition it has nearly finished the installation of an electric plant, which will prove very economical. The stock was in good demand. The actual sales amounted to only 18,675 shares, at $1.10@$1.75, but this is due to the fact that the stock has

FLUCTUATIONS OF MINING STOCKS IN NEW YORK DURING 1892.

Name and Location of Company.	Par Value.	January. H.	January. L.	February. H.	February. L.	March. H.	March. L.	April. H.	April. L.	May. H.	May. L.	June. H.	June. L.	July. H.	July. L.	August. H.	August. L.	Sept. H.	Sept. L.	October. H.	October. L.	Nov. H.	Nov. L.	Dec. H.	Dec. L.	Sales.
Adams, Colo	10	1.75	1.65	1.50	1.25	1.25	1.00					1.00		.90												2,200
Alice, Mont.	25	1.50	1.40	1.35	1.00	.80		.80	.60	.85	.75	.70		.95	.75	.65	.63	.63	.60	.65	.50	.65		.59		11,300
Alpha, Nev	100			.60																		.50				400
Alta, Nev.	100	1.15	.50	1.15	.50	.95	.90									.40				1.35						6,900
American Flag, Colo	100	.02		.02				.02																		1,200
Andes, Nev.	100	1.05		.95	.90																					800
Astoria, Cal	2	.02		.02				.02				.02		.02				.01								12,200
Barcelona, Nev.	25	.06				.05						.19	.15	.14	.05									.08		2,300
Belcher, Nev	100			1.60	1.25									2.00	1.50					4.00		2.40				700
Belle Isle, Nev.	100							.40		.20	.18	.18	.12	.17	.04	.17	.14	.15		.19	.15	.15				5,600
Belmont, Cal	1	.69	.60	.66	.60	.70	.60	.70	.30	.36	.33	.40	.34	.40	.38	.38	.35	.37	.36					.30		42,800
Best & Belch, Nev.	100	3.50	2.20	3.30	2.30	3.25	2.15	2.50	2.25			2.15	1.70	2.00	1.50	1.50	1.25	1.30		3.00	1.70	2.10	1.50	1.55	1.20	8,170
Bodie Cons., Cal.	100					.57	.51	.70	.43	.40	.38	.40	.18	.35	.15	.38	.30	.50	.30	.55	.30	.31	.15	.25	.20	14,320
Breece, Colo.	25					.35		.55	.50	.37		.30		.40	.35	.39	.38			.40		.40				1,900
Brunswick, Cal.	5	.08	.05	.14	.06	.14	.10	.19	.08	.20	.12	.22	.14	.18	.12	.17	.15	.15	.09	.12	.07	.12		.14	.09	305,600
Bullion, Nev.	100	2.00	1.50	1.85	1.35			.70				1.00	.40	.80	.55	.35		.45		1.00	.75	1.00		1.10	.90	5,140
Bulwer, Cal.	100	.45				.45		.55	.47	.45	.42			.40		.35		.35		.35	.34	.30	.25	.20	.15	7,700
Caledonia, Dak.	100	.60		.88	.60	1.10	.94	1.05	.85	.80		.86	.75	.85	.80	1.20	.75	1.15	1.00	.98	.90	.90	.85			11,810
Castle C'k, Idaho	100	.03				.03								.03	.02			.02								5,200
Chollar, Nev.	100	1.50	1.00	1.85				.95		1.00				.95		.60	.50			1.25	.90	1.45	1.05			2,050
Chrysolite, Colo.	50	.20	.18	.27	.20	.25	.21	.23	.18	.24	.20	.25	.15	.18	.15	.16		.18		.22	.15	.19	.15	.23	.15	17,450
Colo. Cent., Colo.	10	1.25	1.20																							1,400
Commonwealth, Nev.	100					.15												.10								500
Comstock Tun., Nev.	100	.23	.13	.20	.16	.17	.15	.17	.12	.16	.12	.14	.12	.19	.12	.13	.11	.15	.12	.17	.11	.12	.11	.09	.08	145,370
Comstock, b'ds, Nev.		.30		.29	.28	.28	.25	20.00	.16	.19	.17	.19	.17			.18	.17	.18	.17	.19	.17	.22	.16			110,400
Comstock scrip, Nev.												.14												.14		2,720
Con. C. & Va., Nev.	100	6.00	3.75	6.00	5.75	5.25	4.30	5.00	3.90	4.70	3.90	4.50	3.70	3.90	3.35	3.60	3.10	4.90	3.05	5.00	3.25	3.40	2.90	2.85	1.10	18,545
Cons. Imp., Nev.	160	.16		.15										.12		.13	.10	.12				.14				4,300
Crescent, Colo.	10					.15																				1,250
Crown Point, Nev.	100	1.70	.85	1.65	1.10	.95		.45				.75		1.20	.85	.65		1.30	.80	1.60	1.30	1.25		1.05	.80	6,494
Challenge, Nev.	100													.75												100
Daly.	20			21.00																						10
Deadwood Terra, Dak.	25	2.10	2.00	2.80	2.00	2.10	1.90	2.15	2.05	2.15		3.20	2.10	2.10	1.20	2.25	2.10	2.15		2.15	2.00			1.50	1.10	6,105
East Sierra, Nev.	100																			.10						600
El Cristo Rep. of C.	2	.50		.40	.35	.75	.41	.75	.65	.50		.40	.29	.45	.35	.30	.25	.45	.25	.40	.35	.35	.18	.22	.20	13,020
Emmett						.55																				300
Enterprize.	10									5.00				5.35	4.75	4.75	4.00	4.20	4.00			3.70		3.50		4,300
Eureka, Nev.	100	2.00								2.10		2.00		2.00	1.90	1.65										800
Excelsior, Cal.	100	.85																								200
Exchequer, Nev.	100	.65		.80	.65	.40								.25												2,700
F. de Smet, Dak.	100					.36	.25			.45	.31	.45	.35	.30	.25	.35	.25	.33	.25	.30		.20		1.24	.23	10,100
Freeland, Colo.	25													.04		.04										4,600
Gould & Curry, Nev.	100	1.80	1.05	2.00	1.30	1.65	1.25	1.60		1.15								1.60	.80	1.90	.17	1.10	.90	1.00	.65	6,755
Hale & N're's, Nev.	100	2.00	1.00	2.90	1.85	1.90	1.30	1.75	1.35			1.55	1.35	1.50	1.20	1.20	.75	2.40	.80	3.40	1.55	1.80		1.70	.90	9,340
Hollywood, Cal.	2							.04						.02				.01		.01						10,600
Del Monte, Nev.	100	.60	.55	.70	.65																					1,100
Grand Prize.	100											.25														200
Homestake, Dak.	100	12.25	12.00									14.50	14.00			14.13	14.00	15.00				13.75	13.50			865
Horn Silver, Utah	25	3.95	3.60	3.90	3.50	3.90	3.60	3.20	3.05	3.35	3.30	3.60	3.25	3.45	3.30	3.65	3.55	3.65	3.60	3.70	3.40	3.55	3.35	3.50	3.25	18,376
Iron Hill, Dak	10													.25										.10		500
Iron Silver, Colo.	20																					.50				100

FLUCTUATIONS OF MINING STOCKS IN NEW YORK DURING 1892.—*Continued.*

	Par Value.	January.		February.		March.		April.		May.		June.		July.		August.		Sept.		October.		Nov.		Dec.		Sales.
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	
Julia, Cons., Nev.	$100			.20	.19					20	.15	.16		.10						.16	.15					3,100
Justice, Nev.	100			.60						.40																1,100
Kingston and Pike, Ont.		.50	.45											.25		.25	.20									2,500
Lacrosse, Colo.	10			.07	.05	.05	.04	.05		.05				.03						.05	.04	.04	.03	.05	.04	13,750
Leadville, Colo.	10	.33	.18	.29	.20	.23	.16	.21	.16	.23	.15	.18	.14	.15	.13	.16	.14	.22	.15	.19	.16	.19	.16	.24	.16	234,274
Little Chief, Colo	50	.30	.27	.32	.22	.25		.28	.24	.27	.25	.27	.25	.29	.25	.26	.24	.29	.24	.25		.25	.24	.25		21,950
Martin White, Nev.	100															.25										700
Mexican, Nev.	100	2.50	1.40	2.90	1.85	2.15	1.85	1.65	1.45	2.60	2.05	1.55		1.60	1.40	1.50	1.35	2.20	1.30	2.30	1.80	1.65	1.45	1.70	1.05	11,245
Middle Bar, Cal.	2											.03						.01								1,400
Monitor, Colo	1							.02																		400
Mono, Cal.	100	.95												.30				.20		.40	.35					1,700
Moulton, Mont	5	.15								.35												.25		.30		900
Mt. Diablo, Nev	100	1.75		1.45																						300
Mutual M. and S., Wash.	1					.42	.40																			1,240
Navajo, Nev.	100	.15		.12	.10	.10		.19	.15	.15		.13	.10	.12		.10	.05			.16	.15					3,600
Nevada Queen, Nev.	100					.75				1.00						.25										300
N. Belle Isle, Nev.	100							.30				.19	.10			.15								.05	.04	1,200
N. Commonwealth, Nev.	100	.55		.47	.45											.30						.05				1,450
Occidental, Nev.	100	2.10																								100
Ontario, Utah	100	45.00		43.00				41.00		40.00				40.00		41.00	39.50			40.50		40.00	14.00	20.00	15.00	4,322
Ophir, Nev.	100	3.75	2.75	3.50	2.75	3.15	2.80			3.15	2.30			2.65	1.75	2.25	1.60	3.25	2.65	3.10	2.50	3.10	2.55	2.75	1.65	7,090
Or'l. & Miller, Nev.	10							.05																		100
Osceola, Mich	25	27.75																								60
Overman, Nev.	100	1.60	1.20	1.65	1.40																					700
Phœnix Lead, Colo.	1															.20										100
Phœnix of Arizona.	100	.81	.39	.74	.49	.55	.44	.45	.42	.45	.37	.63	.50	.60	.43	.59	.50	.59	.48	.56	.50	.56	.50	.65	.50	205,325
Plymouth, Cal.	50	2.25	1.50	3.25	2.00	2.00	1.75	1.70	1.50	1.00	.89	.92	.90	.95	.90	.75		.50		.90	.70	1.00	.75	.75		5,590
Potosi, Nev.	100	2.25	1.35	2.10	1.25	1.40	1.20	1.20				.75				.60	.50	1.30	.70	1.20	1.05	2.25	1.65			5,270
Quicksilver, Cal., c.	100																					17.00	16.00			122
Quicksilver, Cal., p.	100																							19.00	17.00	500
Rappahannock, Va	1	.02	.01																							2,000
Robinson, Colo.	50	.50	.48	.55	.46	.47	.44	.47	.44	.46	.45		.43	.40	.35	.40	.35	.38	.37	.39	.35	.28				13,400
Santa Fe, New Mex.	10											.20		.12												700
S. Sebastian, S. Salvador.	5	.08																								100
Savage, Nev.	100	1.95	1.30	1.65	1.25	1.70	1.15			1.50		1.50		1.50		1.05	.65	2.50	.85	2.00	.75	1.90	.75	1.35	1.10	7,065
Scorpion, Nev	100	.40	.30	.31	.25					.20		.12		.30	.15			.50		.35	.30	.40	.25	.30	.20	7,160
Sg. Bel. and M., Nev.	100	1.00	.70	1.95	.60																					2,800
Shoshone, Idaho	1	.02		.02										.01												7,000
Sierra Nevada, Nev.	100	2.00	1.50	3.75	1.45	1.85	1.45	1.40	1.35			.95	.80	1.15	.85	1.70	1.10	3.10	1.45	2.40	1.25	1.45	1.15	1.40	1.25	7,585
Silver Cord, Colo.	10	.30		.35	.25					.35	.30	.35	.30	.35		.40	.35			.35		.32				12,050
Silver King, Ariz.	100											.34				.03	.03									900
S. M. of L. V. N. M.	1	.40														.40										1,700
Small Hopes, Colo.	20													.95	.90	.95		1.00	.95	1.00	.95	1.00	.90	.95		3,000
Standard, Cal.	100	1.65	1.25	1.40	1.25	1.50	1.10	1.75	1.35	1.45		1.75	1.40	1.65	1.50	1.60	1.45			1.35	1.30	1.50	1.30	1.50		18,675
Stormont, Utah	1	.03																								400
Sullivan Con., Dak.	3									.54	.50	.92	.53	1.10	.94	1.05	1.00	1.05	1.00			.95	.90			10,350
Syndicate, Cal.						.20		.22																		700
Union Cons., Nev.	100	2.00	1.40	1.95	1.45	1.65	1.55	1.40	1.15			1.10		1.15	1.00	1.15	.80	2.20	1.20	1.25		1.75	1.05	1.30	1.05	6,485
Utah, Nev.	100	.65	.45	.60	.35	.50	.25	.40				.05		.40				1.35								10,200
Ward Cons., Colo	10									.25																600
Yellow Jacket, Nev.	100	1.95	.95	1.25	.80	1.30	1.10	1.25	1.00	.80		1.05	.50	1.10	.70	.60	.50	1.70	.60	1.70	1.15	1.25	.85	.95	.60	10,110

Total sales, ...,

been rather closely held. Of the other Bodie mines, Bulwer Consolidated declared dividends aggregating $15,000; but on the whole there was a decline in the value of all these stocks. Plymouth Consolidated suffered a decline from $3.25 in February to 50c. in September. There was not much demand for it, the total sales amounting to only 5590 shares. The mine was closed down in July, and since then it has been filling with water. It has been stated that it does not pay to work the mine, but the company owns valuable water rights, the future of which will soon be determined by the Board of Directors.

Brunswick Consolidated was heavily traded in during the year; according to the official lists 305,600 shares were sold, at prices ranging from 22c. in June to 7c. in October. If it is true, as alleged, that a great portion of these sales were not *bona fide*, it is only justice to say also that many sales were made which were not recorded on the official lists of the Consolidated Stock and Petroleum Exchange. Development work has progressed at the mine during the year, and the prospects, as viewed in the superintendent's official letters, appear more promising than two years ago. Assessments levied by this company during 1892 aggregated $20,000.

Dealings in Astoria, Hollywood, and Middle Bar were as follows: Astoria, 12,200 shares, at 1@2c.; Hollywood, 10,600 shares, at 1@4c.; Middle Bar, 1400 shares, at 1@3c.

The properties of these companies had remained neglected for a long time, and debts were accumulating. With a view to develop these mines a consolidation was effected last fall. The reorganization included, in addition to the three above-named properties, the Littlefield mine. The new company is known as the Albany Gold Mine, and is capitalized at 1,000,000 shares of $1 each. Each share of the old companies entitles the holder to one share of the new. A certain number was set aside for working purposes, and to-day the Albany Gold Mine, in addition to paying off debts amounting to $26,000, has in its treasury $10,000 with which to commence work. The new stock will soon be listed at the Consolidated Exchange.

The Belmont Gold Mine, formerly the Sutter Creek Gold-mining Company, has experienced no boom, thus justifying the prediction made by the *Engineering and Mining Journal* when the reorganization was effected.

The Colorado shares have always been among the most popular. During the past year, however, in common with the majority of mining stocks, they have, with few exceptions, been quiet. Being chiefly silver mines, the low price of their product has had a depressing influence upon the shares.

Leadville Consolidated was one of the favorites during the year. The price fluctuated between 13c. and 33c. The latter quotation, which is the highest of the entire year, was made in January. Since that time the price seldom has been above 22c. The total sales were 234,274 shares. The company declared a dividend of 3c. per share ($12,000) during the year. Of the other Colorado stocks Chrysolite was traded in to the extent of 17,450 shares, at from 15c. to 27c. Enterprise was quiet, only 4300 shares being sold. The price declined from $5.35 to $3.50.

Of the Black Hills stocks Caledonia was not in much favor. Deadwood Terra was in better demand, although but few shares were sold. Father de Smet had a

few sales, but there was not much call for it during the year. Homestake is regarded as a profitable investment, and there never is much buying or selling of it on the Exchange. This company declared $150,000 in dividends during the year; Deadwood Terra paid $100,000. Iron Hill was absolutely neglected, and Sullivan Consolidated, a concern which reputable persons have declared to be worthless, had some "washed" sales. It was reported officially that 10,350 shares were sold, at prices—which there is reason to believe were fictitious—ranging from 50c. to $1.10.

Of the Utah stocks Horn Silver ruled strong and steady during the year and was in good demand. Of all the silver stocks none can show a better record than this. Dividends paid during the year aggegated $200,000, or 50c. per share. The publication of regular financial statements by the Horn Silver Mining Company is an excellent practice, and should be followed by all mining companies. Daly had a solitary sale of 10 shares, at $21. This company has continued to pay regular monthly dividends of $37,500—a total of $450,000 for 1892. Ontario proved one of the greatest surprises of the year, by ceasing the payment of its usual monthly dividends in November. The stock sold for $40@$45 up to that month, when it dropped to $20. The stock reached its lowest price in November, when a few shares were sold at $14. The total number of shares sold amounted to 4322. The fact that the stockholders were left in ignorance of the financial condition gave rise to ugly rumors, which, especially if they were groundless, might have been obviated by the publication of quarterly financial statements, such as those of the Horn Silver Mining Company. The controlling interest is held by a pool composed of the largest stockholders; nevertheless, the small stockholders have rights which should not be denied.

Of the Arizona shares Phœnix stands pre-eminent. It was one of the most popular of the long list of mining stocks traded in at the Consolidated Stock and Petroleum Exchange, and was a favorite at the New York Stock Exchange. The developments at the company's property, as well as the status of its finances, have been satisfactory to the stockholders. The company's mill has started up and is working regularly. The results will be shown within a short time. The company has a good low-grade property.

Silver King was absolutely neglected, despite the rumors at various times that affairs at the mine were in better shape than the stockholders were aware of, and that the "ring" was trying to assess the stock "out of existence."

Of the foreign mining companies whose stock is listed at the Consolidated Stock and Petroleum Exchange, El Cristo attracted the most attention; not that it was in much demand, but, as usual, there were a number of interesting rumors about it and its promoter. However, nothing has come of the rumors, and the long-promised "boom" has failed to materialize. The stock declined steadily from 75c. in March to 20c. in December; total sales, 13,020 shares. Nothing is doing at the mine.

The San Sebastian Gold-mining Company, of Salvador, Central America, has ceased to exist. The company's property was sold at auction Oct. 31 to satisfy a mortgage of $40,000 held by the bondholders, the Atlantic Trust Company, of New York, trustee. The property was bought in by a committee of bondholders representing about $136,000. The price paid was $500, subject to the mortgage of $40,000. At a subsequent meeting of the stockholders the company was

dissolved. It is not known whether a new company will be formed, the bondholders not having agreed upon such action. For the entire year there was one sale of 100 shares.

The stock of the Monte Cristo Gold-mining Company was listed at the Consolidated Stock and Petroleum Exchange early in December. The company was incorporated May 13, 1892, under the laws of Kentucky, with a capital stock of $500,000 in 500,000 shares of $1 each. From the papers submitted to the Exchange we learn that the company owns about 1000 acres in the State of Tolima, Republic of Colombia. The ore is an auriferous gravel. The mine has never before been worked, but $10,000 is being expended in development, and in September 50 men were employed. Hydraulic mining will be inaugurated. The stock is full paid and not assessable, and 50,000 shares were originally set aside for working capital. The officers are as follows: President, Lee R. Shyrock; Secretary, Valentine A. Lewis; Directors, L. R. Shyrock, V. A. Lewis, S. W. Blakely, J. A. Harpending, Frank A. Haight, Charles F. Vincellet, and Joseph V. Clark.

Paris Mining Stock Market.

Nothing of unusual importance occurred during 1892; the standard investment stocks, such as Rio Tinto, Laurium, and Vieille Montagne, held their own, suffering slight declines, if any. El Callao, as in London, fell off with bad reports from the mine. It is quite probable that work on the Callao mine proper will be suspended after the pillars are drawn and the mine allowed to cave; however, there are some prospects of working outside properties which have kept the stock steady at a low figure. The Forest Hill Divide, which company operates mines in Placer County, California, suspended operations during the year, and to this must be ascribed the falling off from 60 francs to 20 francs per share. No new mines of any consequence have been placed on the market, and it may be said that there was less activity during 1892 than in any previous year.

PARIS MINING STOCKS IN 1892.

Name and Location of Company.	Opening, Francs.	Highest, Francs.	Lowest, Francs.	Closing, Francs.
Eastern Oregon, Ore	2.00	17.50	.75	.75
Forest Hill Divide, Cal	60.00	60.00	20.00	20.00
Golden River, Cal	120.00	130.00	120.00	130.00
Golden River, parts	20.00	30.00	20.00	30.00
Laurium	780.00	770.00	700.00	725.00
Lexington, Mont	123.75	135.00	99.75	108.75
Lexington, parts	4.00	4.00	2.40	2.40
Nickel	860.00	982.00	860.00	890.00
Rio Tinto, Spain	482.50	482.50	395.00	427.50
Rio Tinto, Oblig	517.50	520.00	511.25	517.
Rio Tinto, Oblig. (2d)	512.50	517.50	510.00	517.
Tharsis, Spain	151.55	151.25	113.75	124.25
Vieille Montagne, Belgium	545.00	572.50	507.50	518.

The Pittsburg Mining Stock Market.

There was, with very few exceptions, a steady and increasing demand for bank stocks in 1892. This class of securities commanded a much higher premium at the end of the year than at the same period in 1891, due to their conservative management and the excellent returns as shown from their statements to the Comptroller of the Currency. The shares of the insurance companies a few years since were prime favorites with investors, but of late their prestige has waned, until to-day, with scarcely an exception, they are about the lowest in the market. Of the natural-gas companies the Philadelphia Company is by all odds the most active. It is capitalized at $7,500,000, and its bonded indebtedness was $2,500,000, but for some time past it has been buying its bonds at par and interest. How many have been retired is a matter of conjecture. The Chartiers Valley Gas Company is leased to the Philadelphia Company, and its statement of earnings and expenses for the last quarter shows a deficit of more than $20,000. The Pennsylvania Natural Gas Company is also leased to the Philadelphia Gas Company, the latter company guaranteeing 6% per annum on the stock. This agreement has about four years to run, expiring in 1896. After that period it is to receive one half the rate of dividend declared by the Philadelphia Company. The Bridgewater Gas Company has been largely benefited by its oil production, which has enabled it to place itself in such a position that it is at present probably as free from financial difficulties as any other natural-gas company in this vicinity. As for the rest of this group, very little can be said. The public refuses to touch them. The rapid exhaustion of the natural-gas fields is strongly emphasizing the warning so often given in the *Engineering and Mining Journal* concerning the unstable character of these securities.

The New York and Cleveland Gas Coal and Coke Company was the only active coal stock on the list. It ranged from $47 to $52 during the year, and at the close sold for about $51 per share. Of the electric stocks the Westinghouse group are the reigning favorites. The financial difficulties of this company brought it to grief, but it succeeded in getting Eastern capitalists to help it out, and the shareholders seem to be satisfied with the present management of affairs. There are very few transactions in any of the various securities of the company in Pittsburg, and consequently a reliable basis for market quotations is lacking.

THE SALT LAKE CITY MINING-STOCK MARKET IN 1892.

(From our Special Correspondent.)

The business in the Salt Lake City mining-stock market started out well in January and gave indication of a boom, but all ended in shadow. February was unusually quiet, the market showing no life or snap whatsoever. March proved to be the best month of the year, the sales reaching a high figure; but the public demand was soon satisfied, and the market ruled steady and quiet during May and June. July came in with a rush, and took second-best place for activity and amount of sales during the year, while August was almost as lively. The continued low price of silver, with signs of a still further decline, caused a downward tendency in all silver stocks, and depressed every mining share prominent in this market. In consequence September, October, November, and December were the dullest months of the year.

The prices of the various stocks ruled throughout the year as follows: Ontario was quoted during January at $41; the new strike of ore on the 1500-ft. level, in the early part of the year, produced a great demand for the shares, and the price advanced in a few days from $40 @ $41 to $46. The quotation was $46 for some time, until the market followed its natural course and brought the stock down to $40, or a 15 per cent dividend basis. The grand slump of the year occurred in November, when Ontario passed its dividend; the company, to pay dividends, had been drawing upon its surplus to the extent of $50,000 a month, and the end had to come. The stock has lately shown some strength and activity at $15 @ $20, but it is improbable that dividends will be resumed until the great drain tunnel is completed, which will take fully a year longer. It is currently reported here that the company will increase the milling capacity and work more ore, but I do not believe it.

Daly was in strong demand during the entire year at $20 @ $21, and many shares passed into the hands of investors. One of the original owners of this property dumped part of his large holdings on the market in the early spring, but this did not affect the price, and the shares were quickly absorbed at the prevailing quotations. At this writing Daly is down, in sympathy with Ontario. The November dividend was paid, but many holders are afraid of the future, and the stock can be bought for $15. In the first eleven months of the year, Daly sold ore to the amount of $390,369.53 and paid dividends, $412,500, showing a deficit of $22,130.47, and a corresponding decrease in the surplus. On its face, this looks like a remarkably good showing in these days of low silver, but the company has only been able to pay dividends and keep up its surplus by increasing the ore production fully 40 per cent.

Crescent was another stock that gave a surprise to its holders. The stock was steady at 38 @ 40 cents during the early part of the year, but through advices given out by those warranted to speak intelligently, and owing to heavy orders given to buy, the shares were quickly advanced in July to 50 @ 55 cents, and at this price it remained quiet during the summer. It was given out that the company would pay a dividend of at least 10 cents a share, but instead it levied an assessment. The stock can now be had at buyer's price, and one third of the whole is advertised as delinquent. The management is severely criticized, and deservedly so, as the whole thing looks bad.

Anchor and Alliance, both prominent stocks last year, have not shown a color in 1892, and ruled quiet, with none offered for sale and no demands; shares are quoted nominally at $4.50 for the former and $1.25 for the latter. Apex, another high-flier in former times, was quoted during the year at 10 @ 12 cents, with few and small sales. Park City has a new applicant for public favor in the Mayflower and Silver King; stock is held privately, and but little is offered for sale. The company is paying large dividends.

Horn Silver has not shown any activity in this market, and has sold at an average price of $3.50 for the year; the company continues to make large shipments of low-grade ore.

Of the mines of the Tintic District, the once famous Mammoth failed this year to keep up its record of popularity as an investment and speculative stock. No dividends were paid, but an enormous amount of development work was done, which should put the mine in a position to produce ore and pay dividends in 1893. Stock was quoted at $2.15, but there was no demand. Cleveland Consolidated is quiet, at 50 cents. Silver Spar is a new property, with stock in fair demand, and ruling steadily at $1.00. This company is not shipping ore, but is putting in a large amount of money in development. Bullion-Beck, a famous producer and dividend-payer, changed hands to some extent at $7.50 a share. Tetro was in strong demand at 25 cents during the early part of the year, but has now subsided. The one redeeming feature of the Salt Lake stock market for the entire year was the famous Centennial-Eureka. In demand and strong at $55 in March, it has only suffered a decline of $5 a share since that time, although the company ceased to pay dividends in that month, and did not declare any until this month, when they were resumed. The cessation of dividends was due to the erection of a new steam-hoist and the widening out of the main shaft into a double compartment; this prevented the hoisting and shipment of ore, of which the mine has a large amount of remarkably high grade in reserve. The upholding of the stock to the high price of $50 a share is indicative of the great confidence of the stockholders in the mine and management, which is well deserved. The Utah, (of Utah) has been in demand since the property was incorporated into a stock company. The shares pay five cents monthly, and are quoted at $7.50 @ $8.00.

The year as a whole has been fairly good. There have been no "wild-cats" floated that were of any importance, the business of the year being in the main confined to well-known investment stocks. The market at present is suffering under a depression that can only be relieved by a higher price for the white metal.

San Francisco.

The mining-stock market in 1892 was notable in several ways, but not by the activity in trading, or from any interest displayed by the public in its operations. The recorded sales amounted to 3,818,780 shares, as compared with 5,014,695 shares in 1891.

The primary cause for this startling decline was certainly the suit instituted against the Hale & Norcross Company. During the hearing of that notorious case the methods of Comstock operators were fully exposed, and the most unparalleled infamy ever carried on upon systematic lines in connection with mining enterprises had light thrown upon it.

A realization of the methods by which the Comstock mines have been managed has caused many habitués to forsake the vicinity of Pine Street.

As inside operators recognize that the present mode of mine and stock operating must soon end, they have exerted themselves even more than heretofore to mulct the public in as large sums as possible within the time which remains to them. The year 1892 for them was by no means a bad one. Not one dividend was declared by a Comstock corporation, while the immense sum of $2,062,920 was collected in assessments. Even Consolidated California and Virginia,—the bonanza stock,—which during 1891 practically carried the market, during 1892 simply shared with Belcher, Potosi, and Norcross the honor of serving as bait to catch the gudgeons.

On Jan. 12 Consolidated California and Virginia sold for $3.60, gradually advanced, reaching $6.37 on Feb. 5, and declined again on the 25th to $3.65, to allow the closing out of margin accounts, when the insiders again commenced a similar operation. On April 25 and May 7 the ruling rate was $5.12½; it declined to $3 on Aug. 24, rallied to $4.95 on Sept. 23, in sympathy with Belcher's advance, and sold at the close of the year at $1.65.

The deal of the year, however, was made in Belcher, and with the exception perhaps of Hale & Norcross, no series of stock operations has netted more to the manipulators. On July 18 the stock sold for 85c., with a 25-cent assessment collected. Insiders began then to buy, and up to August 24 had purchased 80,074 shares. The stock was still steady at 85c., but between that date and Sept. 22 a line of shorts was caught, and on the 27th the selling price was $6.12½. The price then ran down to $2.75, and between Oct. 1 and Nov. 3 the pool sold out 76,140 shares at an average of $3.20. At the close of December the ruling rate was $1.35. The pool had unloaded and the street held the stock. In order to cover up this stroke of business the ore assays were increased and reports of developments in the mines put in circulation. These tactics stimulated the price of the stock slightly, but it is safe to say that the price will sag below the $1 limit unless an ore development should actually take place, when the above mode of cornering the stock will be repeated.

The management of the Hale & Norcross Company changing early in the year, it was hoped by many that an honest administration would cause the mine to prosper; but as "Jim" Flood was the man at the helm, the *Engineering and Mining Journal* never held such a delusive hope. During the year $168,000 has been collected from three assessments, and the stock has been manipulated so that a handsome return has been secured. In January the ruling rate was 75c., with a 50-cent assessment pending. On Feb. 11 the price had advanced to $2.75 in

sympathy with Consolidated California and Virginia, these two stocks leading the market at that time. Another 50-cent assessment was collected, and on August 24 the stock was quoted at 45c., with the third assessment pending. On Sept. 23 it recovered to $4, the price being put up to close out a small line of shorts, after which it declined to $1.20 on Nov. 4, but rallied to $2.05 at the end of the year.

During January and February the market was most active. Then Consolidated California and Virginia touched $6.37; Ophir, $3.80; Hale & Norcross, $2.75; Savage, $1.85; Potosi, $2.45, and Belcher, $2.40. An exception, however, must be noted when, in April, Ophir was advanced to $4.10 to catch the short interest, and others of the north end advanced in sympathy.

From Jan. 1 to August 24, while $1,463,000 had been collected in assessments, the lode was selling in the market for $1,645,000—a curious indication of the mutability of affairs on the Comstock.

For some months Potosi was the stock of "great expectations." In August it sold as low as 40c., with the mine's indebtedness at $18,846. On Sept. 23 the value of the stock had increased to $1.70; it declined to 85c. on Nov. 4, and on bogus reports recovered on the 17th to $2.45, declining again early in December to $1.85, with an assessment in view, and closed at $1.75. A curious feature of Potosi management has been the more or less constant increase of the battery-assay value of the ore compared with the car-sample value. Despite its bullion production, however, on Dec. 1 the mine was saddled with a debt of $22,194.18.

Of the various group of outside stocks there is nothing to be said. In the Bodie group there was collected $52,500 in assessments. Bulwer Consolidated paid a dividend aggregating $15,000, leaving a balance on hand Dec. 1 of $8330, the stock selling on the same date at 20c. Standard Consolidated also paid a dividend, and for the year, with the improvements in the plant at the mine, has probably made a better showing than in 1891.

The Tuscarora group of mines has long been notorious for the methods of management which have brought the finances of the several companies down to the lowest ebb and made the stocks a drug in the market. Comstock methods obtain, and while the bullion from the mines mysteriously disappears, assessments are regular. During 1891 no less than $195,000 was collected in assessments. Nevada Queen was an exception, for not only was there no assessment, but a dividend of 20c. per share was declared. After payment of the dividend there was left in the treasury $13,589. On Dec. 1 this sum had disappeared, and an indebtedness of $479 was entered against the company, with the stock selling at 5c. At the close of the year the stock was selling at $1.05.

The Coptis (Young America South) cannot properly be said to belong to the Tuscarora group. Three dividends, aggregating 62½c., or $62,500, were declared during the year. The stock is rarely quoted in the market.

The Quijotoa group of Arizona stocks were assessed to the amount of $103,000, and there is no reason to suppose that any change for the better will take place this year. Several mines in the group are veritable "wild-cats," and with the possible exception of Silver King the stocks are not worth carrying, even for a risky gamble. In the case of the last-named stock, while it levied an assessment in 1892 amounting to $25,000, it is reasonably certain that this amount might have been saved and a dividend declared with proper management. The dealings in these stocks have been very small throughout the year.

FLUCTUATIONS OF PRICES OF MINING STOCKS IN SAN FRANCISCO DURING 1892.

Names of Stocks.	Par Value.	January.		February.		March.		April.		May.		June.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Alta, Nev	$100	.70	.45	1.10	.40	.95	.80	1.00	.65	.75	.60	.60	.10
Belcher, Nev	100	...	...	...	...	...	...	...	...	...	...	...	...
Belle Isle, Nev	100	.30	.25	.30	.25	.25	.05	.25	.10	.20	.10	.20	.05
Best & Belcher, Nev	100	3.35	2.00	3.20	2.10	2.40	2.05	2.55	2.15	2.70	2.15	2.30	1.60
Bodie, Con., Cal	100	.65	.55	.70	.45	.65	.45	.55	.30	.40	.30	.30	.15
Bulwer, Cal	100	.75	.35	.50	.40	.45	.30	.50	.35	.90	.35	.45	.40
Chollar, Nev	100	1.50	.85	2.00	1.05	1.35	.90	1.25	.70	1.00	.75	.75	.20
Commonwealth, Nev	100	.25	.15	.45	.10	.15	.10	.16	.10	.25	.15	.15	.10
Con. Cal. & Va., Nev	100	6.00	3.90	6.13	5.00	5.38	4.10	5.25	3.95	4.60	3.80	4.75	3.50
Crown Point, Nev	100	1.55	1.15	1.55	.85	1.10	.70	1.20	.55	1.30	1.15	1.20	.70
Del Monte, Nev	100	.60	.45	.75	.25	.30	...	.20	.10	.20	...	.15	...
Eureka Con., Nev	100	1.85	1.50	2.00	1.50	2.25	1.50	2.25	1.40	2.00	1.20	2.00	1.50
Gould & Curry, Nev	100	1.70	.90	1.90	1.20	1.55	1.25	1.50	1.10	1.60	1.30	1.25	.65
Hale & Norcross, Nev	100	1.90	.80	2.75	1.35	1.75	1.00	1.65	.90	1.60	1.25	1.50	1.10
Mexican, Nev	100	2.35	1.05	2.10	1.60	2.10	1.70	1.95	1.20	2.70	1.40	1.60	1.20
Mono, Cal.	100	.80	.40	1.10	.70	1.15	.75	.80	.60	.75	.50	.60	.25
Mount Diablo	...	1.95	1.25	...	...	1.50	1.00	1.25	1.10	1.25	.70	1.20	1.10
Navajo, Nev	100	.10	...	.10	.05	.20	.05	.15	.05	.10	.05	.10	.50
Nevada Queen, Nev	100	.15	.10	.40	.10	.80	.25	1.10	.50	1.75	.10	1.25	.40
North Belle Isle, Nev	100	.45	.25	.30	.10	.25	.10	.25	.10	.25	.10	.15	.05
N. Commonwealth, Nev	...	.55	...	.50	.30	.30	...	...	...	.30	...		...
Ophir, Nev	100	3.60	2.55	3.35	2.60	3.10	2.60	3.00	2.05	3.40	2.10	2.85	1.75
Potosi, Nev	100	2.10	1.20	1.75	1.10	1.50	1.05	1.90	.90	2.05	.95	.90	.40
Savage, Nev	100	1.80	1.20	1.75	1.15	1.75	1.00	1.60	1.50	1.50	1.30	2.15	1.35
Sierra Nev., Nev	100	1.95	1.55	1.75	1.30	1.85	1.20	1.75	1.10	1.75	1.20	1.30	.79
Union Cons., Nev	100	1.95	1.25	1.95	1.30	1.75	1.30	1.50	.95	1.65	1.15	1.25	1.20
Utah, Nev	100	.60	.35	.50	.35	.45	.25	.40	.20	.45	.30	.25	.05
Yellow Jacket, Nev	100	1.40	.90	1.20	.65	1.25	.65	1.25	.70	1.05	.70	.95	.50

Names of Stocks.	Par Value.	July.		August.		September.		October.		Nov.		Dec.	
		H.	L.	H.	L.	H.	L.	H.	L.	H.	L.	H.	L.
Alta, Nev	$100	.30	.15	.30	.20	.55	.20	.65	.20	.25	.20	.30	.20
Belcher, Nev	100	...	...	...	...	...	...	2.50	2.35	2.50	1.50	1.80	1.30
Belle Isle, Nev	100	.15	.05	.30	.05	.10	.05	.15	.10	.10	.05	...	...
Best & Belcher, Nev	100	1.90	1.40	1.40	1.05	2.60	1.40	3.15	1.40	1.85	1.35	1.55	1.10
Bodie, Con., Cal	100	.15	.10	.30	.25	.50	.25	.60	.20	.30	.10	.20	.10
Bulwer, Cal	100	.45	.40	.35	.25	.40	.25	.50	.25	.25	.15	.15	...
Chollar, Nev	100	.85	.15	.65	.40	1.15	.45	1.55	.75	1.30	.65	1.05	.20
Commonwealth, Nev	100	.10	...	.10	.05	.05	...	...	...	.20	.05	.05	...
Con. Cal. & Va., Nev	100	3.80	3.00	3.55	3.00	4.05	3.15	4.40	2.80	3.25	2.75	2.85	1.10
Crown Point, Nev	100	1.05	.60	.60	.40	1.60	.45	2.10	1.00	1.40	.95	1.05	.15
Del Monte, Nev	100	.05	...	...	...	...	...	...	...	...	...	...	...
Eureka Con., Nev	100	2.00	1.50	2.00	1.50	2.00	1.50	2.20	1.50	2.00	1.50	1.50	...
Gould & Curry, Nev	100	1.15	.50	1.10	.60	1.50	.80	2.00	1.30	1.20	.75	.85	.50
Hale & Norcross, Nev	100	1.35	1.00	1.05	.40	2.50	.60	3.50	1.30	2.10	1.25	1.65	.70
Mexican, Nev	100	1.65	.55	1.45	1.00	2.00	1.40	2.60	1.25	1.90	1.25	1.60	1.20
Mono, Cal	100	.40	.15	.60	.10	.15	.10	.30	.05	.30	.20	.20	.10
Mount Diablo	...	1.20	1.15	1.10	1.05	...	...	1.15	1.00	.95	...	...	...
Navajo, Nev	100	.05	...	.10	...	.10	...	.10	...	.10	.05	.15	.05
Nevada Queen, Nev	100	.50	.35	.20	.10	.15	.10	.15	.05	.05	...	.05	...
North Belle Isle, Nev	100	.15	.05	.20	.05	.05	...	.15	.05	.10	.05	.10	.05
N. Commonwealth, Nev	...	.45	...	...	...	...	...	...	...	...	...	...	...
Ophir, Nev	100	2.70	1.40	2.40	2.00	3.25	2.20	3.70	2.25	3.20	2.05	2.70	1.05
Potosi, Nev	100	.60	.30	.60	.35	1.15	.50	1.60	.85	1.80	.85	2.20	1.30
Savage, Nev	100	1.45	1.00	1.00	.55	1.60	.70	2.60	.75	1.75	.60	1.40	.85
Sierra Nev., Nev	100	1.15	.60	1.30	.85	2.40	1.30	2.70	1.25	1.70	1.10	1.40	1.15
Union Cons., Nev	100	1.15	.70	1.05	.70	1.95	.75	2.50	1.15	1.50	1.00	1.30	.90
Utah, Nev	100	.35	.05	.25	.15	.40	.20	.55	.15	.15	.10	.15	.05
Yellow Jacket, Nev	100	.95	.50	.60	.40	1.30	.45	1.75	.85	1.25	.80	.85	.40

FOREIGN COUNTRIES.

The following tables of mineral productions, imports and exports, have in all cases been derived from the official statistics of the several governments. It will be noticed that the figures here given do not in all cases agree with those in the first part of this book, the most noticeable differences being in the production of silver in Germany; thus on page 214 this is stated at 27,598 kilos for the year 1884 on the authority of the Director of the United States Mint, and on page 529 the amount is given as 248,116 kilos. This difference arises from the fact that the Director of the United States Mint excludes the silver derived from imported ores, and his report was also undoubtedly too small in the amount produced by the German mines.

AUSTRIA-HUNGARY.

Austria.

In 1891 the value of the mineral produce was $41,077,944. In addition there were the products of the salt industry, the value of which was $5,526,643. The value of the output of each Province was as follows: Bohemia, $21,730,786; Lower Austria, $843,193; Upper Austria, $497,479; Salzburg, $260,910; Moravia, $4,580,630; Silesia, $7,180,302; Bukowina, $21,618; Styria, $6,740,137; Carinthia, $1,762,253; Tyrol, $430,821; Carniola, $1,241,839; Dalmatia, $114,864; Istria, $288,306; Galicia, $911,449.

There were in all 643 mines in operation, employing 114,103 men, and 96 smelting works, employing 12,668 men. Of the total number, 126,771, 113,165 were men, 7338 women, and 6268 boys under 19 years of age. The salt works employed 10,353 hands, of whom 6929 were men, 1114 women, and 2310 boys under 19 years.

In the mines there occurred 254 fatal and 385 serious accidents; in the smelting works, 9 fatal and 38 serious accidents, all of which were in the ironworks.

The accidents in the mines were: Coal mines, fatal, 132; serious, 104—total, 236; lignite mines, 99, 230, and 329, respectively; iron mines, 7, 24, and 31; salt mines, 3, 3, and 6; other mines, 13, 24, and 37.

Hungary.

The latest official statistics of the mineral and metallurgical products of Hungary are for the year 1890.

The total number of employees engaged in the industry was 52,132, of whom 44,053 were men, 1947 women, and 6132 boys. The metal mines employed 35.7% of the whole number; the ironworks, 24.3%; the coal mines, 38.4%; other mines, 1.6%.

Greater precaution was taken by the Government than by corporations, for while the former worked 13.32% of the total mine area and employed 17.53% of the hands, only 11.82% of the total 499 accidents occurred in its mines.

The appended tables are taken from the official figures.

MINERAL PRODUCTION OF AUSTRIA.

	1885.		1886.		1887.		1888.		1889.		1890.		1891.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
MINES:														
Gold ore	101	7,036	111	6,310	163	8,321	367	5,550	331	5,138	1,547	9,084	440	7,223
Silver ore	13,883	1,597,313	13,693	1,587,325	13,341	1,666,214	13,922	1,614,976	13,567	1,565,008	14,494	1,583,589	14,538	1,590,442
Quicksilver ore	62,283	302,950	67,354	369,701	70,520	330,133	73,155	401,590	73,395	425,026	70,730	445,808	70,633	517,780
Copper ore	6,244	127,040	6,141	127,569	6,355	165,061	6,618	180,587	7,142	156,849	7,503	171,711	9,318	177,287
Iron ore	931,471	1,130,150	796,116	962,368	846,566	988,636	1,009,320	1,139,635	1,115,153	1,243,936	1,361,548	1,552,882	1,231,248	1,427,444
Lead ore	13,481	473,172	13,821	528,802	15,195	589,953	12,531	568,725	12,826	568,773	11,274	484,811	13,361	534,256
Nickel and cobalt ores	137	1,934	37	193	....	....	....	....	....	....	0 4	159	....	....
Zinc ore	23,598	104,497	21,320	103,032	20,099	110,085	26,312	176,278	30,096	216,455	32,632	279,406	28,828	287,773
Tin ore	1,099	5,525	389	4,661	75	3,503	991	5,570	549	3,637	569	2,584	720	1,800
Bismuth ore	78	13,279	1,206	17,976	1,186	22,436	917	12,364	773	10,687	792	9,516	1,083	12,738
Antimony ore	180	18,762	393	17,490	391	23,768	353	21,021	343	19,656	770	25,940	333	21,287
Arsenic ore	....	....	0.6	10	....	....	....	....	....	....	....	....	4	195
Uranium ore	11	51,536	43	114,026	26	49,190	32	40,180	16	26,589	25	20,837	22	9,657
Wolfram ore	55	12,240	56	10.100	59	8,200	39	5,375	20	3,831	37	6,168	57	10,690
Sulphur ore	9,929	59.318	8,095	47,040	7.519	39,819	11,545	59,554	9,785	60,222	5,422	32,312	3,088	18,602
Alum and vitriol slate	58,609	20,433	65,461	24.128	62.961	27,096	63,039	25,597	65,204	21,161	58,838	17,999	34,394	10,375
Manganese ore	6,158	40,878	9,246	65,263	9,311	61.721	6,554	48,597	3,926	34,159	8,007	51.312	5,279	35,371
Graphite.	16,051	289,643	17,267	263,397	19.796	314,125	19,646	317,373	22,336	351,061	23,728	363,018	21,346	346,663
Asphaltum	100	819	291	2,730	330	3.402	316	3,034	369	3,187	181	1,480	180	1,404
Lignite	10,514,153	9,129,067	10,931,352	9,337.365	11,573,172	9,491.283	12,860,255	10,370,539	13,845.863	11,430,556	15,329,056	13,819,557	16,183,076	15.384,528
Coal	7,378,665	11,334,509	7,421,278	11,153,717	7,796,151	11,433,727	8,274,461	11,985,156	8,592,876	13,323,968	8,931,064	15,200,535	9,192,885	16,342,346
SMELTING WORKS:														
Gold, kilos	25	17,485	16	11,582	16	11,441	9	6,960	13	8,836	21	14,546	14	9.636
Silver, kilos	36,076	1,607,099	35,696	1,590.264	35,181	1,568,437	35,325	1,577,214	34,435	1,578,576	35,862	1,598,792	36,037	1,609,524
Quicksilver	487	470,022	541	588.835	532	645,512	541	702,645	566	768,507	542	798,281	570	691,841
Copper	592	179,257	744	213.084	896	268,911	889	360,365	863	291,819	992	301,081	1,033	292,360
Pig-iron	499,097	10,312.136	485,313	9,493,061	511,777	9,396.215	586,121	10,920,514	617,012	11,793,727	666,273	13,650,308	687.145	12,440,547
Lead	8,525	627,281	8,048	620,229	7,826	613,940	7,993	670,233	8,218	701,382	8,297	699.747	7,583	603.052
Litharge	3,306	215,474	3,084	209,490	2,836	211,466	2,697	224,612	2,302	183,619	1,913	148,277	2,267	176,529
Nickel sulphate	....	....	....	....	....	....	....	....	....	....	....	....	1.5	225
Zinc	3,948	325,945	3,843	316,306	3,609	319,749	4,001	434,557	4,840	550,514	5,449	733.920	5,006	687,538
Tin	35	20,572	42	23,919	31	22,910	38	27,734	56	35,149	50	29,718	56	31,859
Bismuth	2	9,225	0.28	1,243	0.16	764	....	....	0.1	524	0.1	957	0.64	2,803
Antimony	191	32,150	203	30,708	258	38,238	213	32.779	221	37,896	200	41,792	115	22,659
Uranium salts	9	96,945	12	181,597	....	44,352	0.7	7.776	3.8	39,802	4	32,106	4	22,622
Sulphur	88	3,921	101	5,092	105	5,362	109	6,451	40	1,427	37	1,321	45	1,708
Sulphuric acid	11,559	249,679	12,025	392,794	12,792	329,852	10,788	206,291	9,732	261,178	11,334	220.973	12.268	187,288
Pyrites	3,225	45,221	3.195	45.349	4,702	47,873	3,850	40.761	3,539	34,399	3,717	33,298	2.831	24,261
Copperas	2,049	30.768	1,398	21,003	958	13,515	1,019	14,950	1,082	17,020	1,296	19,491	1,184	16,579
Copper sulphate	28	4,631	161	21,257	95	10.217	69	7,226	158	21,310	338	54,402	198	21,143
Alum	1,949	65,696	1,808	63,930	2,129	78,388	1,683	62,587	1,547	56,303	1,464	50,816	427	37,170
Mineral paints	1,099	12,509	255	4,554	554	10,489	646	9,533	773	11,002	778	11,068	838	12,675

AUSTRIA-HUNGARY: MINERAL PRODUCTS IMPORTED.

Years.	Coal.		Raw Copper.		Pig-iron.		Machinery, Locomotives, etc.		Mineral Oil.		Stone Manufactures.	
	Metric Tons	Dollars.	Met. Tons.	Dollars.	Metric Tons.	Dollars.	Met. Tons.	Dollars.	Metric Tons.	Dollars.	Met. Tons.	Dollars.
1881	2,148,100	4,312,000	4,990	2,005,080	80,340	1,535,170	32,619	6,765,920	147,651	5,956,440	46,588	3,710,280
1882	2,146,400	5,242,510	5,428	2,267,230	100,649	1,972,250	40,856	9,673,090	125,260	5,110,700	55,939	4,742,710
1883	2,368,200	5,055,820	6,646	2,474,990	131,892	2,455,880	37,452	7,820,890	110,259	4,765,250	53,667	4,478,600
1884	2,478,200	5,769,750	6,248	2,112,390	92,827	1,455,300	37,256	8,399,090	134,960	5,241,530	54,523	5,297,880
1885	2,507,000	5,839,820	5,809	1,650,810	48,783	764,890	27,448	5,807,480	140,602	4,630,500	49,015	4,383,540
1886	2,663,868	6,464,080	5,238	1,360,240	54,765	805,070	21,545	4,738,790	128,847	3,606,400	55,764	4,350,220
1887	2,755,182	6,727,210	5,149	1,444,030	49,138	746,270	23,008	5,477,220	113,300	2,752,330	54,289	6,966,330
1888	3,122,163	7,620,480	3,769	1,639,050	62,830	943,250	25,255	6,957,020	120,257	2,743,510	38,271	7,404,880
1889	3,229,250	8,066,870	7,872	2,103,080	82,929	1,252,930	32,626	10,221,890	139,529	3,305,540	41,084	8,349,110
1890	3,628,300	12,571,440	8,878	2,769,970	66,793	1,151,010	30,010	8,872,430	129,106	2,943,920	41,245	7,994,350

AUSTRIA-HUNGARY: MINERAL PRODUCTS EXPORTED.

Years.	Coal.		Glass and Glassware.		Iron and Ironware.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
1881	3,642,900	5,816,300	32,951	8,229,550	50,410	10,800,580
1882	3,469,200	5,885,390	36,832	9,871,540	41,313	8,187,410
1883	4,046,500	7,233,380	37,160	10,551,170	42,504	5,761,420
1884	4,103,100	7,487,690	40,702	10,611,930	36,750	5,697,720
1885	4,101,900	7,653,310	38,483	9,749,530	39,669	5,448,800
1886	4,488,900	8,438,780	40,525	9,528,540	41,624	5,837,860
1887	4,721,900	8,971,900	45,041	10,016,090	55,054	7,192,220
1888	6,089,600	11,536,070	42,579	8,342,250	41,819	5,629,610
1889	6,501,200	14,160,510	42,062	7,240,240	45,878	6,760,530
1890	7,403,200	15,903,440	39,055	7,539,630	60,360	10,073,910

MINERAL PRODUCTION OF HUNGARY.

(Metric tons of 2204 lbs. 2 florins = $1.)

	1886.		1887.		1888.		1889.		1890.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
Gold .... kilos	1,788.7	1,247,711	1,862	1,298,638	1,806.4	1,287,583	2,215.2	1,488,626	2,131.2	1,486,520
Silver .... "	16,042.9	721,911	17,665	794,092	16,963	748,856	17,229.5	764,297	17,049.7	767,236
Copper..	371	106,889	339	92,185	383	119,856	305	90,793	275	78,417
Lead....................	2,105	131,786	1,779	110,192	1,995	139,313	2,385	188,095	1,255	90,061
Zinc	....	....	....	....	....	....	....	....	76	2,378
Quicksilver............	7	7,712	9	10,599	10	12,761	10	12,603	8	10,127
Antimony ore	38	10,698	238	14,422	198	14,965	1,110	19,487	224	20,295
Antimony	254	34,328	236	37,326	303	55,714	339	67,358	352	68,592
Nickel & cobalt ore	409	39,391	176	34,023	336	30,780	366	26 563	340	24,284
Nickel & cobalt speiss..	77	17,325	65	14,652	38	7,831	47	10,492	59	1,189
Pig-iron	234,667	3,992,980	190,929	3,248,502	204,106	3,564,524	238,900	4,380,879	295,507	5,670,262
Coal.	859,197	2,172,738	786,408	1,894,020	850,691	2,025,505	937,451	2,233,727	994,812	2,415,654
Lignite	1,567,614	2,291,251	1,706,534	2,471,161	1,874,201	2,578,294	1,950,226	2,907,028	2,249,098	3,417,508
Briquettes..............	18,074	68,972	17,461	67,122	23,389	89,562	22,796	89,927	25,183	99,438
Coke.....................	....	....	....	....	....	....	10,291	42,704	20,026	86,673
Asphaltum..	967	1,431	733	4 008	1,146	5,438	628	5,023	2,189	37,203
Mineral oils.............	....	....	16	428	45	2,478	....	....	....	....
Sulphur	23	822	30	1,050	41	1,435	41	1,452	63	443
Manganese ore..........	2,192	9,988	963	5,332	622	4,006	2,109	3,056	3,774	7,675
Litharge....	355	25,276	231	16,491	132	9,656	360	32,116	405	36,065
Sulphuret of carbon....	8	775	47	4,512	103	9,766	194	15,159	266	15,280
Mineral paints.	300	4,500	250	4,375	190	3,700	172	3,345	237	3,243
Sulphuric acid..........	560	2,847	767	3,489	864	2,643	2,059	11,607	1,559	10,978
Gold litharge...........	13	148	9	106	32	172	....	....	....	... ...
Iron pyrites............	45,324	129,434	50,262	137,816	45,959	127,097	52,416	271,912	....	....
Alum....................	50	30	50	30	....	....	1,050	787	525	386
Iron vitriol	....	....	....	....	251	2,786	244	2,708	244	2,708
Realgar...........	25	1,500	22	554	6	16	168	630	....	....
Iron ore	631,431	871,708	558,968	715,125	*a*	*a*	*b*52,416	*b*140,281	*c*56,746	*c*147,223
Salt.....................	152,222	6,649,710	159,898	7,016,794	....	......	....	... ...	... ...	......

(*a*) Iron ore exported of the value of $309,195. (*b*) Exclusive of iron ore exported of the value of $352,403.
(*c*) Exclusive of iron ore exported of the value of $359,220.

BELGIUM.

By Victor Watteyne, M.E.

Coal.—In the coal industry the year 1873 is looked back upon as the most prosperous on record, and it was followed, as was also 1890, by years of depression. The production of coal, after having fallen off a little in 1891, has begun to increase—compensating in a measure for the smallness of the profits. In the following and all the tables the franc is taken to be equal to 20c.

PRODUCTION OF COAL IN BELGIUM.

Year.	Tons.	Dollars.	Value per Ton.	Profits.	Profits per Ton.	No. of Workmen.	Annual Wages.
1871	13,733,176	30,760,600	2.24	2,858,000	.21	94,286	$173
1872	15,658,948	41,711,800	2.66	7,105,800	.45	98,863	209
1873	15,778,401	67,527,400	4.28	18,699,000	1.19	107,902	271
1874	14,669,029	48,182,000	3.28	4,592,400	.31	109,631	237
1875	15,011,331	45,968,000	3.06	2,579,200	.17	110,720	233
1876	14,329,578	38,823,800	2.71	751,600	.05	108,543	206
1877	13,938,523	30,591,400	2.19	− 221,400	− .02	101,343	167
1878	14,899,175	29,564,200	1.98	− 308,600	− .02	99,032	168
1879	15,447,292	28,999,000	1.88	− 34,800	− .002	97,711	162
1880	16,866,698	33,936,000	2.01	769,200	.05	102,930	184
1881	16,873,951	32,740,800	1.94	− 293,800	− .02	101,351	186
1882	17,590,989	35,179,200	2.00	955,200	.05	103,701	185
1883	18,177,754	36,955,400	2.03	911,600	.05	106,252	201
1884	18,051,499	34,406,400	1.91	1,251,800	.07	105,582	183
1885	17,437,603	30,923,600	1.77	1,387,400	.08	103,095	162
1886	17,285,543	28,508,400	1.65	1,030,200	.06	100,282	157
1887	18,378,624	29,534,800	1.61	1,748,200	.10	100,739	163
1888	19,218,481	32,403,600	1.69	2,505,200	.13	103,477	174
1889	19,869,480	37,543,600	1.89	4,385,400	.22	108,382	186
1890	20,365,960	53,700,600	2.64	11,752,000	.58	116,779	223
1891	19,675,664	49,490,800	2.52	7,172,200	.36	118,983	217
1892*	20,500,000	44,485,000	2.17	......	......	......	......

* Estimated.

In the following table is shown the difference in production for the first six months of 1891 and 1892:

	Mines.	Output, Tons.	Stocks, Tons.
First half of 1891	130	9,094,389	481,915
" " " 1892	128	9,736,185	1,201,233
Increase in 1892	2	641,796	719,388

It will be noticed that the stocks increased very largely, and so despite the large production the trade has been less active in 1892 than in the previous year. About Oct. 1 the stocks were nearly exhausted, but the market fell and they quickly increased again.

The following table gives the contract prices made with the Belgic State Railways at different times:

Fuel.	Prices in Francs.				
	April 8, 1890.	April 7, 1891.	August 18, 1891.	April 8, 1892.	June 7, 1892.
Charleroi:					
Type II	14.70	8.74	7.00	4.60	....
" III	15.50	10.75	9.15	5.00	5.20
" IV	17.25	10.50	9.80	7.52	7.50
Coking coal:					
Type I	19.50	12.44	11.25	9.75	9.20
" II	19.50	13.00	12.12	......	....
Liege:					
Type II	14.30	9.00	7.50	5.80	6.10
" III	16.00	10.37	9.00	7.30	7.30
" IV	16.87	12.12	11.12	8.37	8.40
Coking Coal:					
Type I	21.00	13.70	12.50	10.00	10.00
" II	....	13.50	12.70	10.50	10.60

The following tables show the variation in our coal trade in the last three years:

EXPORTS, METRIC TONS.

	Coal.			Coke.		
	1890.*	1891.*	1892.*	1890.*	1891.*	1892.*
Germany†	315,495	321,958	282,453	230,090	182,841	311,360
England	37,901	34,518	56,540	....	....	....
France	2,203,203	3,134,531	3,105,583	682,607	579,615	473,244
Netherlands	121,488	125,290	136,811	....	....	....
Other countries	131,262	117,267	107,179	9,762	16,564	23,610
Total	3,809,349	3,733,564	3,688,566	922,659	779,020	808,214

IMPORTS, METRIC TONS.

	Coal.			Coke.		
	1890.*	1891.*	1892.*	1890.*	1891.*	1892.*
Germany†	367,439	401,355	378,237	27,799	90,774	148,443
England	482,117	457,661	362,447	6,108	17,197	101
France	256,223	244,054	265,867	5,932	1,257	2,222
Netherlands	‡323,138	‡248,798	‡210,516	‡3,152	‡5,477	‡1,548
Other countries	67	4,523	119	....	....	....
Total	1,428,984	1,356,391	1,217,886	42,991	114,705	152,314

* First ten months. † Including Luxemburg. ‡ Coming from England or Germany.

The following table shows how the price of coke has fallen:

Year.	Ovens.	Employees.	Tons.	Price per Ton.
1890	4,535	2,722	2,176,755	$4.72
1891	3,855	2,463	1,742,075	3.73

In 1892 the price fell to from \$2.40 to \$2.50 per ton.

The depression in selling prices of coal was followed by a reduction in wages. In 1891 the daily wages of employees under ground was 83c. and above ground 52c., giving a total average of 66c., while in 1892 this average was 52@56c. If we leave out of consideration the women and children, we find that the average wages for men was 91c. in 1891 and only 70c. in 1892.

Notwithstanding this lowering of wages, no strike of any consequence took place during the year.

The Government of Belgium has, in the last few years, enacted many laws, most of them excellent, relating to labor and laborers. I quote the following sections of one which came into force Jan. 1, 1892: "ART. VI. Children under sixteen years of age, and girls between sixteen and twenty-one, shall not be employed between 9 P.M. and 5 A.M. . . . As regards the mines, the kingdom can give permission to certain workmen to engage in night-work, and can authorize the employment after 4 A.M. of boys more than twelve years of age . . ." "ART. IX. After Jan. 1, 1892, no girl under twenty-one shall be employed under ground."

It will be interesting to watch the effects of this law; meanwhile, in order to know the situation at the beginning of the application of the law, I give from the *Statistique des Mines et Usines*, of M. Harze, the table of people employed in the mines of Belgium on Jan. 1, 1892 :

Above Ground: Males above 16, 38,014; 14 to 16, 3116; 12 to 14, 1978. Females above 21, 3056; 16 to 21, 5822; 12 to 16, 5484.

Under Ground: Males above 16, 155,891; 14 to 16, 12,150; 12 to 14, 5070. Females above 21, 1446; 16 to 21, 4570; 14 to 16, 1366.

The number of accidents in coal mines has been about the same in 1892 as in 1891, but the number of resulting deaths has increased greatly, on account of two serious fire-damp disasters. The first, on May 11, at the Charbonnage des Bois de la Haye, in Hainault, where 160 were killed; the other, Sept. 1, at the Charbonnage de l'Agrappe, in the same province, where 25 miners lost their lives. This last accident was due to a sudden outburst of gas, which choked the men—a phenomenon of which we have the unenviable monopoly in Belgium. At Charbonnage des Bois the fire-damp exploded, but the cause has not yet been determined.

Other Minerals.—The metallic mines, formerly prosperous, are now almost exhausted, and most of the ore used is imported. In 1891, 1,500,915 tons of iron ore were imported, and during the first ten months of 1892 the imports reached 1,411,812. The following table gives the amounts of various ores mined in 1891:

Iron ore	202,204 tons—value,	\$234,540	Pyrites	9,990 tons—value,	\$3,820
Lead ore	70 " "	1,620	Manganese ore	8,498 " "	50,920
Zinc ore	14,280 " "	210,680			
Total					\$501,580

The phosphate industry passed through several fluctuations in 1892, the prices being generally low. However, the low-grade phosphates are in fair demand, for they are needed to mix with the high grades imported from several countries, especially Florida. The progress of this industry is evidenced by the fact that the output of 15,745 tons in 1880 increased in 1891 to 291,080, but the value at the

same time fell from $7.20 to $3.46 per ton. Prior to 1889 Hainault was the only province engaged in this industry, but in that year mining was commenced in Liege.

Metallurgy.—Our metallurgy, especially the iron industry, has been much depressed of late years; this has probably been in a great measure due to the substitution of steel for iron for many purposes. The blast-furnaces suffer less than the mills and forges. It is expected that next year, when the patent right expires, many plants will be erected for making steel by the basic process. The following table shows the progress of Belgian metal-working establishments for the last five years:

BLAST-FURNACES.

Year.	Foundry Pig.		Forge Pig.		Bessemer Pig.		Thomas Pig.		Total Production of Pig-iron.		Mills, Forges, Rails, Plates, etc.		Cast Steel.		Steel Works, Forged Steel.	
	Tons.	Value per Ton.	Tons.	Value per Ton.	Tons.	Value per Ton.	Tons.	Value per Ton.	Tons.	Value per Ton.	Tons.	Value per Ton.	Tons.	Value per Ton.	Tons.	Value per Ton.
		$		$		$		$		$		$		$		$
1887	68,511	10.00	516,518	8.33	167,628	10.70	3,119	10.02	755,781	9.02	534,056	23.81	229,321	15.66	191,445	22.73
1888	59,914	10.60	607,193	9.19	157,129	11.77	2,614	9.26	826,850	9.79	547,818	25.58	243,647	16.62	185,417	24.28
1889	60,766	12.40	586,776	9.74	168,493	13.20	16,181	11.80	832,226	10.69	577,204	28.00	261,397	19.72	214,561	27.19
1890	70,253	13.52	526,644	11.64	165,943	15.80	24,996	13.30	787,836	12.71	514,311	32.27	246,566	22.80	201,817	30.99
1891	56,241	11.78	445,436	10.18	147,913	14.01	34,536	11.40	684,126	11.20	497,380	29.20	243,913	19.60	206,305	28.22

The following table shows that in 1892 the prices were lower than in the preceding year:

Description.	Prices per Ton.				
	Jan. 1, 1890.	Jan. 1, 1891.	Jan. 1, 1892.	April 1, 1892.	Nov. 1, 1892.
	$	$	$	$	$
Foundry pig, Luxemburg	18.00	11.20	10.80	9.80	9.20
Forge pig, special	21.00	11.80	11.60	11.00	10.80
" "	18.00	10.80	10.60	10.00	9.80
" " metis	17.00	9.80	9.60	9.00	8.80
" " Luxemburg	16.00	9.80	9.40	9.40	8.80
Bars No. 1, f. o. b., Antwerp	36.00	27.00	24.00	23.00	23.00
Joists, f. o. b., Antwerp	38.00	26.00	23.00	23.00	23.00
Ship angles	39.40	30.00	26.00	26.00	26.00
Plates No. 2, f. o. b., Antwerp	44.00	32.00	28.60	27.00	27.00

On Nov. 1, 1892, out of a total of 47 furnaces 26 were in blast, of which number 15 were running on forge pig, 3 on foundry, and 8 on Bessemer and Thomas pig, producing respectively per 24 hours 1235, 225, and 695 metric tons. The total production in metric tons of these three classes of pig for the first ten months of 1892, compared with the corresponding period of 1891 (the latter figures being placed first), was: Forge pig, 341,980-387,575; foundry pig, 45,435-58,530; Bessemer and Thomas pig, 137,298-183,570—totals, 524,713-629,675. So it is evident that the iron as well as the coal production of 1892 is in excess of that of 1891 in spite of the fall in prices.

The following table shows the exports and imports since 1880:

BELGIUM.

Year.	Imported.								Exported.	
	Coal.		Raw Copper and Nickel.		Iron Ore, Pig, Scrap.		Iron and Steel Manufactures.		Coal.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1880..	917,000	2,641,000	3,887	1,710,400	1,143,004	5,101,600	16,401	1,211,200	4,525,000	13,032,200
1881..	1,016,000	2,885,000	4,953	2,179,200	1,371,008	5,426,400	15,576	1,561,200	4,477,000	12,714,000
1882..	1,044,000	3,027,600	5,699	2,507,800	1,392,183	5,399,000	9,982	994,600	4,292,000	12,446,800
1883.	1,263,000	3,663,600	6,246	2,748,400	1,800,329	6,312,000	7,126	674,600	4,441,000	12,879,800
1884..	1,224,000	3,242,800	7,074	3,112,400	1,627,628	5,133,600	4,545	413,400	4,619,000	12,240,800
1885..	1,238,000	3,107,600	7,639	3,361,000	1,511,216	4,556,400	4,226	351,400	4,338,000	10,889,200
1886..	1,003,000	2,566,800	5,707	2,510,800	1,367,478	4,292,600	4,452	318,800	4,273,000	10,938,400
1887..	1,017,000	2,501,000	5,755	2,532,000	1,611,114	5,254,400	5,393	430,000	4,591,000	11,294,200
1888..	1,035,000	2,721,600	4,202	1,848,800	1,983,319	6,868,200	5,892	558,600	4,467,000	11,777,000
1889..	1,006,000	2,897,400	6,705	2,279,800	2,068,567	7,359,600	7,818	888,000	4,597,000	13,270,800
1890..	1,721,000	6,025,400	6,516	2,215,400	1,908,697	7,382,200	8,264	788,600	4,851,000	17,170,400

Year.	Exported.										
	Coke.		Glass.	Iron Manufactures.		Iron Rails.		Machinery.	Stone, Rough and Hewn.	Zinc, Unwrought.	
	Tons.	Dollars.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Dollars.	Dollars.	Tons.	Dollars.
1880..	850,346	3,401,400	9,911,600	199,656	6,998,400	28,169	788,800	8,722,600	11,632,800	45,317	5,891,200
1881..	914,885	3,531,400	10,888,000	203,134	7,155,000	35,136	983,800	11,268,600	12,126,000	53,650	6,974,400
1882..	1,095,000	4,466,000	10,583,000	247,223	8,609,000	21,345	597,600	15,477,200	12,418,400	49,138	6,387,800
1883..	997,000	4,186,000	11,320,400	266,607	9,253,200	9,455	264,800	14,481,400	14,974,000	55,255	7,183,200
1884..	854,000	3,075,400	9,681,200	263,372	7,173,800	19,742	473,800	10,943,800	19,767,800	63,110	8,204,400
1885.	849,000	2,970,600	9,778,400	261,852	6,553,600	10,185	224,000	8,539,200	12,187,000	61,536	5,538,200
1886..	908,000	3,087,000	9,788,000	271,392	6,327,400	12,208	268,600	8,256,800	11,538,800	62,156	4,972,600
1887..	927,000	2,965,000	10,893,400	306,360	7,169,000	29,351	645,800	8,086,200	12,603,200	68,227	6,140,400
1888..	1,061,000	3,818,800	9,062,400	299,254	7,578,000	10,444	229,800	5,631,000	11,842,800	62,264	5,603,800
1889..	1,220,000	4,928,600	9,222,600	318,569	8,768,200	14,642	351,400	8,622,400	11,614,600	67,489	6,344,000
1890.	1,065,000	5,570,800	8,968,800	266,156	8,176,800	12,853	359,800	9,305,000	4,556,200	67,026	6,300,400

	Imports.		Exports.	
	1891, Tons.*	1892, Tons.*	1891, Tons.*	1892, Tons.*
Steel, crude cast	6,580	5,812	864	907
" rails.	995	487	42,423	60,879
" bars, plates, and wire	3,390	6,399	9,885	9,823
" manufactured	843	959	5,419	7,890
Iron, pig	144,278	113,584	14,440	14,326
" scrap	18,431	19,781	6,382	8,354
Wire	4,231	3,950	2,264	1,905
Rails	155	49	20,705	13,924
Plates	1,258	1,029	36,627	44,989
Other descriptions	13,391	12,520	187,786	189,735
Nails	97	554	6,923	5,647
Castings	1,268	1,151	21,801	19,516
Rolling-stock	1,793	1,109	30,449	33,529
Machinery	13,556	12,218	29,274	29,971

* For the first ten months.

CANADA.

British Columbia.

A correspondent furnishes the following information concerning the mining industry in the Province of British Columbia in 1892 :

" Notwithstanding the fact that nearly 3000 prospectors have been in the West Kootenay district during the past eighteen months, not more than 20 mines are working in silver-lead ore this winter. The Slocan locality produces the richest silver-bearing lead ores, running from 150 to 2000 oz. per ton in silver and about 60% lead. The great drawback to the country so far has been the cost of transportation. A wagon trail, however, from Kaslo City, on the Kootenay Lake, to the Slocan country is in course of construction, and 15 or 20 miles are now finished. The cost of packing the ore for 22 miles is $40 per ton, and some of the mines eight miles farther north pay as high as $8 per ton more. The ore is carried to Kaslo, and thence to Bonner's Ferry by steamers for $2 per ton. The Northern Pacific Railway transports the ore from the Ferry to Helena, Mont., for $8 per ton. Of the 17 companies working this winter in this district 15 are Americans, 1 English, and 1 Canadian.

" The owner of the Wellington, the Kootenay and Columbia Prospecting and Mining Company, of Ottawa, Canada, has shipped two car-loads to the smelters at Tacoma and Smelter, Mont., which gave returns of from 242 to 376 oz. silver per ton, $2.10 gold, and 60% lead. This company is introducing an American diamond drill to test the depth of the veins in the district. The owners of the Freddie Lee have contracted for the transportation of 1000 tons of high-grade ore to Tacoma this winter. Their ore averages 200 oz. silver and 60% lead. During the past summer about 300 tons of ore were packed out from the Slocan district on mules. A wagon road at a cost of $30,000 was built this season by subscription by the Kaslo town-site people and mine owners. When completed, this will reduce the packing charges to about $8 per ton from the Slocan district to Bonner's Ferry, or say $16 through to the smelters in Montana.

" The mineral veins in the Slocan district are from 10 in. to 4 or 5 ft. in width. The deepest shafts at present are down a little more than 200 ft. The ores are richest in silver below a depth of 30 or 40 ft.

"New mines were discovered late last season in the Slocan country, on Johnston and Jackson Creeks. The surface indications are the best yet discovered, but owing to the high altitude of the locality and a heavy snow-fall about the end of October, operations had to be discontinued for the winter. The veins exposed on five or six locations are from 4 to 7 ft. in width; the ore is mixed with vein material, but is rich. Three or four claims or prospects have been sold to Spokane parties, at from $30,000 to $50,000 each.

"The Silver King Company recently sold its property on Toad Mountain, about 9 miles from the town of Nelson on the Kootenay Lake, for $2,000,000. About $100,000 had been expended in sinking shafts and running drifts, and some $200,000 worth of ore had been put on the dump. It is understood that the purchasers, a Glasgow syndicate, will commence the erection of smelters early next season. The Silver Queen Company and three or four smaller concerns employ from 20 to 40 men, but the bulk of the work done on Toad Mountain up to date has been prospecting. The ore is peacock copper mixed with quartz, and is found in pockets, in some cases from 40 to 60 ft. wide and from 30 to 100 ft. in length.

"In East Kootenay all the mines have shut down for the winter. In the Illecillewaet district the oldest worked property is the Lanark, whose owners talk of erecting a smelter next season. In June last a car-load of ore was taken from the Jumbo, owned by Messrs. Corbin, Kennedy, Ross & Co., and shipped to Scotland for treatment. In October the British North American Development Company made a shipment from six of its claims purchased last season from local prospectors, sending the lot to England for treatment.

"A strong Canadian company will operate next season on a copper property on Fish Creek, and for silver at the head of Caribou Creek. Fishburn & Co., at Fish Creek, and Forbes & Co., of the Golden Smelter Company, will also push work on their properties at Fish Creek and Illecillewaet. In the Murdock district a 10-stamp mill for the treatment of gold quartz was put in by Asquith & Co. in July, and 200 or 300 tons of quartz were crushed, yielding in gold about $9 per ton. In the Okanogan district Messrs. Reynolds & Co. of London, Eng., are erecting mills for the treatment of gold quartz, and speak very highly of the prospects. The chief complaint of prospectors in the Kootenay district is that in the richest localities they have great trouble in getting rid of the slide rock, slash timber, and in some cases heavy surface soil. The Government of British Columbia promises to build wagon trails to the principal mining camps next season.

"The British Columbia Mining Act is very liberal. Silver claims must be recorded two weeks after staking. The recording fee is $2.50. After $400 in assessment work has been done the fee-simple may be obtained on payment of $5 per acre. The new Mining Act of 1892 makes the size of a claim 1500 ft. with the vein and 1500 ft. across. A claim can be held for 12 months by the expenditure of $100 in assessment work, and the fee-simple to a lot may be obtained at any time on payment of $500. Wages in the Kootenay district range from $3 to $4 per day for good men."

New Brunswick.

By Prof. L. W. Bailey.

Granite.—Four concerns were engaged in quarrying granite at St. George, Charlotte County, in 1892, and their output for the year would approximate 1300 tons, valued at $104,000. These figures are for dressed and polished stone, all the firms being fully equipped for doing all the work on the spot. The granite in the rough, when quarried, would cost about $12 generally, though for getting out large blocks it costs more. The finished work (which is chiefly monumental) is shipped throughout the Dominion, a considerable trade being done with Manitoba and British Columbia. The largest part, however, is shipped to Ontario, a small per cent only going to the United States. The wages paid out by the different firms would amount to upward of $5000 per month in the aggregate. The Burpee Company, late of St. John, now removed to Calais, Me., owns a quarry in St. George, from which is procured what stock it requires. I am informed that it handles 300 or 400 tons per annum.

The St. George granite is of red color, and is highly esteemed for the richness of its hue.

Albertite.—This mineral, the so-called Albert coal, was at one time extensively mined near Hillsborough, in Albert County. The following description and history of the mine is from Appendix C, Report of New Brunswick Crown Land Department:

"Though at present apparently exhausted, no mineral found in New Brunswick has awakened greater interest or has possessed a higher pecuniary value than this. First discovered in the year 1850, its development was for some time retarded by litigation, but immediately after the settlement of this difficulty its prosecution was so rapid and its value found to be so great, that in the years 1863–65 the annual export amounted to from 18,000 to 20,000 tons, worth at Hillsborough from $20 to $22 per ton. Although not identical with asphalt (differing in solubility and in some other respects), albertite is more nearly related to this than to coal, and is of the nature of an oxygenated hydrocarbon, derived probably originally from veins of fluid petroleum. Its mode of occurrence is quite like that of ordinary veins, being sometimes coincident with the bedding, but as often oblique or at right angles to the latter, besides varying greatly in thickness in different parts, and sending off innumerable smaller veins or veinlets, sometimes forming a complete network of the latter. The principal deposits, those of the Albert mines, occur in highly bituminous and petroleum-bearing shales, situated at or near the base of the Lower Carboniferous formation, and these are undoubtedly the original source of the mineral, but smaller veins are occasionally found penetrating both underlying and overlying strata.

"The maximum thickness of the vein at Hillsborough, as found near the surface, was 22 ft., and was found to occupy a nearly vertical fissure, which was mined to a depth of over 1400 ft. The mineral is jet black in color, highly lustrous, breaking much like asphalt, and entirely destitute of stratification, being also destitute of microscopic structure, and of uniform quality throughout. It softens under the influence of heat and ignites readily, burning with a sooty flame. Sub-

jected to distillation it yields 100 gallons of oil per ton, and of gas about 14,500 cu. ft., the latter being of superior illuminating power. From it a burning oil, known as albertine, was for a time manufactured, but its principal use was as an enricher in gas manufacture, for which it was highly esteemed.

"The decline of the Albert mine was as remarkable as its development. As early as 1870 indications of diminished supply began to be observed, and though every effort was made to ascertain the possible existence of other deposits of similar character in the immediate vicinity, these were found unavailing, and the mine, having been practically exhausted, was in 1879 finally abandoned. In the mean time, however, similar explorations were carried on at more remote points, chiefly by boring, while a careful survey of the area was undertaken by direction of the Dominion Government, and all available information bearing upon its further occurrence obtained and published. These surveys resulted in demonstrating the existence of albertite veins at widely separated points, in connection with the inclosing Albert shales; but these were in all cases very small, and though considerable sums have in some instances been expended in proving them, they have in no instance proved remunerative."

The following information relates to recent attempts at further development, and is given on the authority of Dr. A. H. Chandler of Salisbury, N. B.:

"Early last spring a vein of seven inches of albertite was opened, and two or three tons taken out, near the summit of East Albert Hill (about three miles west of the old Albert mines and in the same shale belt). This coal is of superior quality, fully equal to that raised at the Albert mines of former days. Various outcrops have been discovered in the locality, more particularly in that portion of the property now controlled by Mr. J. De Wolfe Spurr of St. John. Albertite has also been discovered and a vein of six inches located and opened by Dr. A. H. Chandler of Moncton, at Taylor Village, Westmoreland County. Several barrels were taken out. The vein has been traced eastward several hundred feet, until it plunges under the shales that come up in the bed of the river."

Cannelite.—This mineral, called cannelite by Dr. Chandler, is really a highly bituminous shale or pyro-schist, though at times approaching true cannelite.

"Cannelite exists also at Taylor's Village, Rockland, in three veins (lying conformable to the surrounding strata of Albert shales) of 5 ft., 7 ft., and 18 ft., respectively. A shaft was sunk several years ago in the 5-ft. vein to the depth of 45 ft. by the Westmoreland and Albert Mining Company. A company is now being organized under the name of the Victoria Cannelite and Albertite Company of Rockland, for the further prosecution and development of the property.

"During the past summer a large field of Victoria cannelite was prospected at Baltimore, Albert County, and in October 25 tons were raised and shipped to Boston, Mass., from a 7-ft. lead. A test has recently been made in the retorts of the Cambridge Gaslight Company at East Cambridge, Mass., and it compared with some other coals as follows: 13,334 cu. ft. of gas from Bog Head cannel, 9883 cu. ft. from Newcastle, 11,043 cu. ft. from Victoria cannelite. This test was from samples of the cannelite of inferior quality from the top of the lead; and it is estimated, that as the work proceeds the yield may be 20% more, along with considerable increase in illuminating power."

Newfoundland.

Though Newfoundland is not in the Dominion of Canada, yet we have here included it under the general heading of Canada.

Our correspondent in this ancient colony writes us that the copper mines at Little Bay have been shut down, and the smelting-works, which have produced nearly 100 tons best select ingots per month for several years past, have also been closed, and a large number of men thrown out of employment. This mine, it is said, has not paid for some years, the vein becoming less and less productive, and there is little hope that it will be reopened. The Tilt Cove mine is being vigorously worked, and is at present producing about 5000 tons per month of ore carrying about 4% copper. Some of the best of this ore is shipped to England, and a few thousand tons have been sent to New York; the larger part is smelted at the mines in small brick cupolas, and the matte forwarded to England for further treatment.

The pyrites mine at Pilley's Island is also being vigorously worked, the greater part of the production being sent to New York for the extraction of the sulphur, of which it carries about 50%. This deposit is not now considered as large or as durable as it was at first supposed to be. The district of Notre Dame Bay, in which these mines are situated, is thought to contain many large deposits of copper and other ores, but the best of the lands, or a large proportion of them, are held by speculators, who have no disposition to prospect or develop them.

The French have some fishing privileges on the northern and western shores of the island, on which good mineral deposits are known to exist, but the terms of the old treaties give the French power to prevent the working of these. It is hoped that some agreement will be made with the French Government which will lead to the opening of the mineral lands on the so-called French shore and give employment to the population settled around the coast, who can do nothing in the long winter season.

Nova Scotia.

During the year 1892 mining matters generally were dull. The mild winter of 1891–92 left the domestic and railway supplies of coal less depleted than usual, and the time-honored system of developing gold mines on the surface only was responsible for some diminution in the yield of gold.

Coal.—During the past season in Cumberland County the most noticeable events were the consolidation of the Joggins mines with a number of other coal areas between Macan and Joggins, and the introduction of rope haulage at the Springhill mines, where a large number of horses have been replaced by about twenty-five miles of rope.

In Pictou County the Intercolonial Company did a large business, working double shifts for some time. The reopening of the workings in the main seam was interrupted by the breaking out of spontaneous fires in the old workings.

In Cape Breton County business was conducted as usual. The demand for house coal was unusually limited, and the St. John's (Newfoundland) demand was insignificant until the close of the year.

Coal-cutting machinery has been introduced at several mines, with fair results. It is reported that a number of Boston capitalists have secured options on the mines in operation in this county, and expect to effect shipments to the United States by barges *via* Louisburg.

Pending the publication of the Government statistics, available figures give the sales for the year as follows: Cumberland County, 460,000 tons; Pictou County, 415,000 tons; Cape Breton County, 870,000 tons—a total of 1,745,000 tons, against 1,849,945 tons in 1891.

Iron.—A fair activity has been shown in this line. The Londonderry Company has disposed of its make to local and Dominion foundries, and has equipped a mine at Torbrook, Annapolis County, which yields about 250 tons of ore a day. The New Glasgow Iron Company has a furnace running in Pictou County, on the limonite ores of the East River, and a charcoal furnace is making an excellent pig-iron from similar deposits at Bridgeville. In all about 35,000 tons (2240 lbs.) of pig-iron have been made and about 75,000 tons of ore raised. The New Glasgow furnace only went into blast in the fall.

Manganese.—See article on "Manganese," by R. A. F. Penrose, Jr.

Gold.—The total output in 1892 was 23,500 oz. For further information concerning the gold-mining industry in Nova Scotia, see "Gold and Silver."

Plaster.—The usual amount of gypsum was shipped from Windsor to the United States, and a few thousand tons were sent from Cape Breton to Montreal. The total sales, including plaster ground for fertilizers, etc., amounted to 165,000 tons.

Building Materials.—About 12,000,000 brick were made, in addition to a small quantity of drain-tiles, etc. The amount of building-stone quarried was insignificant, a few thousand tons only having been sent from Wallace and Pugwash to Montreal, etc. About 35,000 tons of limestone were extracted, principally for fluxing.

Summary.—The value of Nova Scotia's mineral product in 1892 may be stated as follows: Coal, \$2,617,500; iron ore, \$150,000; gold, \$443,900; gypsum, \$160,000; brick, \$84,000; stone, \$100,000; limestone, \$70,000; manganese, \$4500—total, \$3,629,900.

ONTARIO.

The mining industry of Ontario is steadily growing in importance, but owing to the limited amount of capital in the Province which seeks investment in this direction, and the lack of experience in mining on the part of the population, progress is not so rapid as has been anticipated by many. Another obstacle is the artificial wall between Canada and the United States erected by the tariff laws of the two countries, which on the one side shuts out the mineral products of Canada from

their natural market and on the other increases the expense of machinery and supplies necessary for the exploitation of the mines. The legislation affecting the mining industry enacted in the Provincial Parliament during the past few years has also retarded the development of the mineral industry.

The most important mining region of Ontario at the present time is the Algoma nickel-copper district, which has been developed wholly since 1887, and is now the second largest producer of nickel in the world. The chief mines are the Copper Cliff, Evans, Stobie, Murray, Blezard, Worthington, and Chicago. Statistics of the production of nickel in this district, and a review of operations in 1892, will be found under the caption "Nickel," in the first part of this book.

A few gold mines are worked in the vicinity of Rat Portage, and several silver mines in the Lake Superior country, of which Port Arthur is the center. Some of the latter have been opened on an extensive scale, but the production of gold and silver in Ontario is still unimportant. There is much activity in the gold district in the neighborhood of Marmora and Deloro, Ontario, where several small mills are running with profit. This is undoubtedly one of the most attractive gold districts in Canada, and will become an important producer at some time, but the total lack of mining enterprise in Canada retards its development.

There are extensive iron belts in Western Ontario, where the Atik-Okan district has attracted considerable attention. The Belmont mine, in the township of Belmont, county of Peterborough, has been exploited to a considerable extent, but during the past few years the iron-mining industry of Ontario has not been in a prosperous condition.

Salt is found in Ontario in an area lying south of a line drawn in the vicinity of Kincardine, Wingham, and Brussels, and west of one drawn south from Brussels to Seaforth. The salt beds run south and west into Ohio and Michigan, and developments in Ontario have taken place chiefly on the northeast edge. In the borings which have been made, one or more beds are met with at a depth of about 1000 ft., varying in thickness from 20 to 100 ft. The quantity known to exist is very large, and the quality of the product is said to be excellent. The production of salt in Ontario in 1892 amounted to 43,387 tons, valued at $162,700.

Other important branches of the industry in Ontario are mica and phosphate mining, and the oil-wells of Petrolia. Statistics of the production of these substances will be found under their respective captions.

Quebec.

The most important mineral products of the Province of Quebec are asbestos, phosphate rock, and mica. The production of asbestos and phosphate rock in 1892 was considerably less than in the previous year, and the phosphate-mining industry, in particular, experienced a great depression. Comprehensive reviews of these subjects, statistics, etc., will be found under the captions "Asbestos," "Phosphate," and "Mica." The promising gold placers of the Chaudière River are still neglected.

The following table is compiled from the annual reports of the Mining and

MINERAL PRODUCTION OF THE

Number.		1886. Metric Tons.	1886. Short Tons.	1886. $	1887. Metric Tons.	1887. Short Tons.	1887. $	1888. Metric Tons.	1888. Short Tons.	1888. $
1	Antimony ore	603	665	31,490	530	584	10,860	313	345	3,696
2	Arsenic	109	120	5,460	27	30	1,200	27	30	1,200
3	Asbestos	3,138	3,458	206,251	4,191	4,619	226,976	3,996	4,404	255,007
4	Baryta	3,506	3,864	19,270	363	400	2,400	1,000	1,100	3,850
5	*Bricks. M.	....	139,345	873,600	....	181,581	986,689	....	165,818	1,036,746
6	*Building stones.(cub. yds.)	....	165,777	642,509	....	262,592	552,267	....	411,570	641,712
7	Cement (bbls.)	....	....	....	....	69,843	81,909	....	50,668	35,593
8	Charcoal (bush.)	....	901,500	54,000	....	1,610,900	88,823	....	1,500,000	87,000
9	Chromic iron ore	54	60	945	34	38	570	....	....	....
10	Coal	1,898,345	2,091,976	4,017,225	2,149,629	2,368,891	4,758,590	2,412,100	2,658,134	5,259,832
11	Coke	32,120	35,396	101,940	36,686	40,428	135,951	41,173	45,373	154,181
12	Copper (in ore)	1,590	1,752	354,000	1,479	1,630	342,345	2,524	2,781	667,543
13	Feldspar and quartz	....	....	....	....	....	....	....	....	....
14	Fertilizers	....	....	....	*452	*498	*25,943	497	548	21,600
15	Fire-clay	....	....	....	....	....	....	....	....	....
16	Flagstones sq. ft.	....	*70,000	*7,875	....	*116,000	*11,600	....	*64,800	*6,580
17	Glass and glassware	....	....	....	....	....	....	....	....	*375,000
18	Gold	kg.1,797	oz. 76,879	1,330,442	kg.1,549	oz. 66,270	1,178,637	kg.1,433	oz. 61,310	1,098,610
19	Granite	5,501	6,062	63,309	19,253	21,217	142,506	19,376	21,352	147,305
20	Graphite	454	500	4,000	272	300	2,400	136	150	1,200
21	Grindstones	3,648	4,020	46,545	4,802	5,292	64,008	5,230	5,764	51,129
22	Gypsum	147,005	162,000	178,742	139,753	154,008	157,277	159,607	175,887	179,393
23	*Iron	....	....	....	28,609	31,527	1,087,728	40,789	44,949	1,592,931
24	Iron ore	63,256	69,708	126,982	69,265	76,330	146,197	71,313	78,587	152,068
25	Lead (in ore)	....	....	....	93	102	9,216	306	337	27,472
26	*Lime (bush.)	....	1,535,950	283,755	....	2,269,087	394.859	....	2,216,764	339,951
27	Limestone for flux	....	....	....	15,582	17,171	17,500	15,297	16,857	16,533
28	Manganese ore	1,623	1,789	41,499	1,130	1,245	43,658	1,634	1,801	47,944
29	Marble and serpentine	*455	*501	*9,900	*220	*242	*6,224	173	191	3,100
30	Mica	kg.9,255	lbs. 20,361	29,008	kg.10,038	lbs. 22,083	29,816	kg.13,193	lbs. 29,025	30,207
31	Mineral paint	....	....	....	*91	*100	*1,500	360	397	7,900
32	Mineral water (galls.)	....	....	....	....	....	....	....	*124,850	*11,456
33	*Miscellaneous clay products	....	....	112,910	....	....	182,150	....	....	....
34	Moulding sand	....	....	....	*145	*160	*800	*153	*169	*845
35	Nickel (lbs.)	....	....	....	....	....	....	....	....	....
36	Ochre	318	350	2,350	349	385	2,233	....	*d*	*d*
37	Petroleum (bbls.)	....	486,441	437,797	....	763,933	595,868	....	733,564	755,571
38	Phosphate	18,598	20,495	304,338	21,497	23,690	319,815	20,404	22,485	242,285
39	Pig-iron	*20,138	*22,192	*237,768	22,529	24,827	366,192	19,781	21,799	313,235
40	Platinum (oz.)	....	....	....	kg. 33	oz. 1,400	5,600	kg. 35	oz. 1,500	6,000
41	Pottery	....	....	....	....	....	....	....	....	*27,750
42	Precious stones	....	....	....	....	....	....	....	....	....
43	Pyrites	38,935	42,906	193,077	34,522	38,043	171,194	57,603	63,479	285,656
44	Salt	56,587	62,359	227,195	54,603	60,173	166,394	53,602	59,070	185,460
45	Sand and gravel (exports)	586,708	646,552	143,641	....	....	....	236,778	260,929	38,398
46	Silver (ozs.)	....	....	*209,090	....	....	349,330	....	....	395,377
47	Slate	4,850	5,345	64,675	6,676	7,357	89,000	4,822	5,314	90,689
48	Soapstone	45	50	400	91	100	800	127	140	280
49	Roofing cement	....	....	....	....	....	....	....	....	....
50	Steel	....	....	....	6,648	7,326	331,199	8,669	9,553	472,611
51	Sulphuric acid	....	....	....	2,485	2,738	70,609	3,959	4,363	121,515
52	Terra alba	3,630	4,000	24,000	....	....	....	....	....	....
53	Terra cotta	....	....	....	....	....	....	....	....	*49,800
54	*Tiles and sewer-pipes	....	....	142,617	....	....	230,068	....	....	380,377
55	Whiting	68	75	600	68	75	600	27	30	240
56	Other products	136	150	156	....	....	1,610,499	....	....	397,172

* Incomplete.

(*a*) Report gives 980.

(*b*) Exports.

(*c*) Statistics for iron, steel, and charcoal not collected in 1890.

Mineral Statistics of Canada, published by the authority of Parliament:

DOMINION OF CANADA.

1889.			1890.			1891.			
Metric. Tons.	Short Tons.	$	Metric Tons.	Short Tons.	$	Metric Tons.	Short Tons.	$	Number.
50	55	1,100	23	26	625	9	10	60	1
...	...	...	23	25	1,500	18	20	1,000	2
5,547	6,113	426,554	8,947	9,860	1,260,240	8,167	9,279	999,878	3
...	*d*	*d*	1,672	1,842	7,543	...	...	...	4
...	200,561	1,273,884	...	211,727	1,266,982	...	176,533	1,061,536	5
...	341,337	913,691	...	382,563	964,783	...	187,685	708,736	6
...	90,474	69,790	...	102,216	92,405	...	93,473	108,561	7
...	1,593,300	93,463	...	*c*	*c*	...	...	...	8
...	...	...	...	...	...	...	...	...	9
2,467,766	2,719,478	5,584,182	2,829,093	3,117,661	6,496,110	3,085,734	3,623,076	8,144,247	10
49,491	54,539	155,043	51,225	56,450	166,298	51,800	57,084	175,592	11
3,090	3,405	885,424	2,729	3,007	902,050	4,324	4,465	1,160,760	12
...	...	...	817	700	3,500	622	685	3,425	13
703	775	26,606	1,092	1,203	31,889	...	...	...	14
363	400	4,800	...	...	...	227	250	750	15
...	14,000	1,400	...	17,865	1,643	24,773	27,300	2,721	16
...	...	150,000	...	...	537,130	...	...	...	17
kg. 1,691	oz. 72,328	1,295,159	kg. 1,497	oz. 64,046	1,149,776	kg. 1,193	oz. 51,303	930,614	18
9,253	10,197	79,624	12,075	13,307	65,985	9,977	13,637	70,056	19
218	242	3,160	159	175	5,200	236	260	1,560	20
3,089	3,404	30,863	4,432	4,884	42,340	4,064	4,479	42,587	21
193,533	213,273	205,108	205,544	226,509	194,033	184,705	203,605	206,251	22
66,453	73,231	2,763,062	...	*c*	*c*	21,680	23,891	...	23
76,389	84,181	151,640	69,429	76,511	155,380	62,594	68,979	142,005	24
75	82	6,604	51	57	5,085	267	295	25,607	25
...	2,948,249	362,848	...	2,501,079	412,308	...	1,829,894	251,215	26
20,074	22,122	21,909	16,768	18,478	18,361	10,323	11,376	11,547	27
1,320	1,455	32,737	1,205	1,328	32,550	249	235	6,694	28
73	*a e*80	*e*980	708	*e*780	*e*10,776	217	240	1,752	29
kg. 16,604	lbs. *b*36,529	*b*28,718	kg. 350,436	lbs. 770,959	68,074	...	...	71,510	30
721	794	15,280	...	...	...	818	900	17,750	31
...	424,600	37,360	...	561,165	66,031	...	427,485	54,268	32
...	...	239,385	...	...	...	...	...	...	33
154	170	850	290	320	1.410	209	230	1,000	34
...	...	...	kg. 652,610	lbs.1,435,742	933,232	kg. 2,103,012	lbs.4,626,627	2,775,976	35
...	...	...	...	...	...	...	...	...	36
...	639,991	612,101	...	765,029	902,734	...	755,298	1,004,546	37
28,120	30,988	316,662	28,814	31,753	361,045	21,405	23,588	241,603	38
23,522	25,921	499,872	...	*c*	*c*	...	...	...	39
kg. 23	oz. 1,000	3,500	...	...	4,500	...	...	10,000	40
...	...	...	...	...	195,242	...	...	258,844	41
...	*d*	*d*	...	...	700	...	...	1,000	42
65,540	72.225	307,292	44,671	49,227	123,068	59,312	67,731	203,193	43
29,793	32,832	129,547	39,704	43,754	198,897	40,854	45,021	161,179	44
256,846	283,044	52,647	310,488	342,158	65,518	221,165	243,724	59,501	45
kg. 8,961	oz. 383,318	343,848	kg. 9,367	oz. 400,687	420,662	kg. 9,713	oz. 414,523	406,233	46
6,293	6,935	119,160	5,779	6,368	100.250	...	...	...	47
177	195	1,170	832	917	1,239	522	575	863	48
...	...	...	1,063	1,171	6,502	817	1,020	4,810	49
*25,293	*27,873	*973,282	...	...	...	...	...	...	50
...	...	...	...	...	700	...	...	...	51
4,990	5,499	152,592	5,044	5,559	145,235	...	...	...	52
...	...	...	...	...	90,000	...	...	113,103	53
...	...	134,265	...	...	488,877	...	...	368,699	54
...	...	...	454	500	500	...	...	...	55
...	...	992,838	...	...	995,667	...	...	...	56

(*d*) Included under mineral paints.
(*e*) Marble only.

MINERAL EXPORTS FROM THE DOMINION OF CANADA.

Metric tons of 2204 lbs.

	1888.		1889.		1890.		1891.		1892.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
Asbestos	3,484	228,355	4,724	323,886	6,670	444,159	7,035	513,909	7,435	514,412
Agricultural Implements	....	155,219	....	321,341	....	367,198	....	252,620	....	402,778
Barytes	....	....	....	....	9	850	9	1,190	....	....
Brick	....	....	....	....	....	5,168	128	858	504	2,750
Charcoal	....	....	....	....	....	31,634	....	61,323	....	46,817
Cement	....	†	....	....	....	322	....	1,746	....	1,495
Cinders	....	....	....	....	....	6,902	....	5,884	....	5,451
Clay, manufactures of	....	....	....	....	....	....	....	50	....	120
Coal	572,576	1,730,466	656,097	2,232,154	727,091	2,447,936	847,351	2,916,465	960,619	3,195,467
Coin and bullion	....	....	....	....	....	....	....	129,324	....	306,447
Coke	....	....	....	....	356	1,050	7	21	....	....
Copper ore	1,533	95,585	1,287	195,182	1,429	111,086	3,129	269,169	345	30,755
Copper matte, regulus, etc.	....	....	....	....	217	23,924	780	64,719	....	....
Copper (fine)	462	50,900	69	7,602	816	109,327	1,414	171,308	1,723	185,848
Explosives	....	....	....	....	9	19,219	61	66,153	75	61,763
Fertilizers	....	....	....	....	....	4,291	....	5,128	....	8,763
Glass and glassware	....	1,352	....	8,396	....	9,668	....	5,521	....	1,964
Gold-bearing quartz, etc	....	810,352	....	623,479	....	657,022	....	554,126	....	316,177
Grindstones	....	31,974	....	23,544	....	21,673	....	24,568	....	23,465
Gypsum (crude)	126,556	133,238	179,766	189,491	177,981	193,899	175,323	184,977	181,444	194,304
Iron and steel, and manuf. of	....	423,488	....	296,719	....	294,928	....	257,461	....	243,857
Lime	....	*100,547	....	*131,066	....	175,184	....	153,265	....	124,152
Metals, other than iron and steel, manuf. of	....	....	....	40,215	....	36,639	....	42,633	....	17,495
Mica (crude and cut)	3	6,884	17	32,505	16	34,865	74	19,666	618	63,708
" (ground)	127	1,883	214	3,128	....	2,453	....	2,646	....	4,758
Mineral oil, galls	455,501	66,834	110,470	18,601	358,804	15,812	436,516	18,726	440,906	18,217
Nickel in ore	....	....	....	....	....	....	2,428	240,499	6,911	617,639
Ore antimony	417	10,777	59	1,942	63	1,520	....	....	4	60
" iron	13,766	39,945	25,157	60,289	14,037	31,366	14,888	32,582	7,833	36,935
" lead	10	724	....	18	4	2,000	....	....	30	5,200
" manganese	1,433	24,760	1,578	29,027	1,817	37,697	894	16,218	168	6,106
" silver	552	299,420	219	168,265	242	201,615	314	238,367	330	193,441
Phosphates	22,207	397,493	23,537	364,583	30,202	401,827	24,653	422,200	17,526	380,462
Plumbago	117	1,025	101	802	53	1,905	....	163	67	438
Salt	4,874	10,044	500	3,750	225	1,522	228	1,429	130	763
Sand and gravel	221,170	33,236	254,431	42,067	335,052	60,359	329,433	63,326	233,537	60,285
Slate	31	525	27	398	24	3,268	....	....	64	1,507
Stone	....	83,872	....	67,783	....	91,998	....	68,308	....	60,209
Tin	....	....	....	....	....	6,410	....	12,615	....	5,115

From the official Trade and Navigation Reports of the Dominion of Canada. Fiscal years ending June 30.

* Includes cement. † Included with lime.

MINERAL IMPORTS OF THE DOMINION OF CANADA.

Metric tons of 2204 lbs.

	1888.		1889.		1890.		1891.		1892.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
Brass †	....	540,010	....	536,650	....	563,245	....	603,043	....	537,105
Bricks and tiles	....	143,775	....	131,475	....	105,818	....	120,667	....	81,495
Cement	....	190,504	....	197,580	....	328,110	....	313,767	....	287,729
Clays	....	53,269	....	53,170	....	61,848	....	56,766	....	82,619
Coin and bullion	....	2,175,472	....	575,251	....	1,083,011	....	1,811,170	....	1,818,530
Coal, anthracite	2,172,341	5,290,412	1,307,189	5,193,025	1,221,029	4,595,727	1,421,969	5,224,452	1,503,353	5,640,346
Coal and coke	1,306,603	3,588,725	1,339,685	3,377,212	1,523,523	3,692,121	1,725,312	4,274,631	1,769,347	4,333,490
Copper †	....	410,858	....	405,504	....	484,189	....	563,522	....	431,427
Earthenware and china	....	697,082	....	697,949	....	695,206	....	634,907	....	748,810
Glass	....	1,203,537	....	1,205,090	....	1,230,585	....	1,247,692	....	1,257,858
Gold and silver †	....	220,355	....	231,285	....	256,164	....	244,042	....	261,471
Gunpowder	....	100,158	....	104,722	....	127,578	....	110,515	....	136,171
Iron and steel †	....	10,482,208	....	12,225,962	....	13,524,899	....	13,826,492	....	12,625,422
Lead †	....	272,435	....	285,571	....	380,242	....	325,455	....	317,142
Metal, composition, and other	....	375,500	....	365,407	....	352,859	....	351,809	....	373,819
Minerals	....	24,335	....	33,435	....	32,763	....	28,250	....	35,552
Mineral oils ... gallons	4,895,066	449,446	4,925,680	518,664	5,244,108	546,051	5,321,524	550,925	5,793,636	494,004
Ores of metals	....	9,027	....	1,393	....	551	....	3,797	....	7,893
Precious stones and jewelry	....	709,863	....	684,322	....	560,961	....	425,012	....	344,827
Salt	88,329	253,111	86,144	284,817	....	309,840	....	380,550	....	380,958
Stone and marble †	....	267,881	....	321,091	....	385,468	....	392,941	....	276,005
Tin †	....	1,164,273	....	1,243,794	....	1,289,756	....	1,206,918	....	1,594,205
Whiting	....	20,508	....	22,735	....	27,471	....	27,504	....	26,867
Zinc	....	65,827	....	83,935	....	92,530	....	105,023	....	127,302
Other products of mines	....	69,395	....	79,442	....	69,804	....	56,915	....	63,658
Other metals	....	5,175	....	142,408	....	197,355	....	191,730	....	199,777

From the official Trade and Navigation reports

* Fiscal years ending June 30. † And manufactures of.

The Canadian Mineral Production in 1892.

The statistics of mineral production in the Dominion are collected for the most part with commendable promptness, and though those for 1892 are not all yet available, we are enabled through the courtesy of the chief producers and of the Provincial mine inspectors and the railroads to give the production of all the more important minerals and metals produced in the Dominion in 1892.

These reports indicate a growth in the Canadian mineral industry, but not such a development as the magnificent natural resources of the Dominion would justify. In the west, where American enterprise has control of many mineral deposits, the progress is most rapid. In the rich mineral fields of Nova Scotia, where fine deposits of coal, of iron ore, of copper, of gypsum, of gold and other minerals are in close proximity to each other and to water transportation, the growth of the mineral output has been surprisingly slow, betokening a lack of enterprise in her people. Such ideal natural advantages should long ago have made that ancient Province an important factor in the industry.

The growth of the Canadian mineral industry can be easily traced in the accompanying table. The copper output has increased 270% within six years, and is certain to increase in the future. The gold production, on the contrary, has declined one third in the same period, and this notwithstanding the excellent properties in Nova Scotia and Ontario. The iron-ore output is stationary, and there is but little pig-iron industry in the Dominion, notwithstanding its natural advantages.

Nickel has become, next to coal, the most valuable mineral product of Canada. Its production commenced only four years ago, and already amounted to 2082 tons in 1892, which, however, was less than in 1891. The value of nickel, which had been counted at 60c. per lb., has declined greatly during the past year, and contracts can now be made at 35c. per lb. for the nickel in nickel oxide, the form in which steel-makers use it. It seems probable that in the early future the market price of this metal will reach still lower figures. The greater part of the Canadian nickel is refined and converted into oxide in the United States, though a good deal of it will then be exported to Europe, where the low price at which it is offered will make it a very serious competitor of the New Caledonia metal.

The asbestos industry of the Dominion increased from 1886 to 1891, but receded in 1892, as did also the phosphate production. The causes affecting the production of the chief minerals and metals, and the detailed information concerning them, are to be found under the caption of each substance in the first part of this book. The latest statistics and current information of interest are to be found in the *Engineering and Mining Journal* from week to week.

Nova Scotia.—Mr. E. Gilpin, Inspector of Mines for Nova Scotia, reports the production of the Province in 1892 as follows :

Coal	1,942,000 tons.	Iron ore	75,000 tons.
Gold*	21,000 oz.	Manganese ore	111 "
Gypsum	162,000 tons.		

* This was given in an earlier report by the inspector, p. 512, as 23,500 oz.

In the article on Manganese (p. 336) this production is given as 50 tons, but the fuller reports since received bring it up to 111 tons.

Ontario.—Mr. Archibald Blue, Director of the Bureau of Mines of Ontario, reports the mineral production of that Province in 1892 as follows (tons used are of 2000 lbs.):

	Quantity.	Value.		Quantity.	Value.
Apatite ....Tons	2,181	$21,810	Mica ....Tons	7	$1,500
Brick (common) ....No.	200,000,000	1,120,000	Natural gas..........................	....	160,000
Brick (pressed) ....No.	20,342,000	198,350	Natural-rock cement......Bbls.	54,155	38,580
Brick (fancy pressed)........No.	1,323,000	32,253	Nickel.......................Tons	2,082	590,902
Building stone..................	....	870,000	Petroleum.................Bbls.	800,000	1,000,000
Cobalt ....Tons	8¼	3,713	Portland cement..........Bbls.	20,247	47,417
Copper.......................Tons	1,936	232,135	Pottery..........................	....	60,000
Draining tile..............No.	10,000,000	100,000	Roofing tile................No.	383,000	8,613
Gold ore.....................Tons	3,510	34,800	Salt...........................Tons	43,387	162,700
Gypsum.....................Tons	2,200	8,000	Silver ore...................Tons	10	732
Lime.......................Bushels	2,600,000	350,000	Terra cotta......................	....	19,119

Quebec.—Mr. J. Obalski, Inspector of Mines for Quebec, has reported to us the mineral output of that Province in 1892 as follows, in tons of 2000 lbs.: Asbestos, 5,492 tons; building material, granite, etc., 100,000 cubic ft.; copper ore (of which 53,415 tons were shipped), 57,641; gold 350 ounces (from alluvial workings a further amount was taken out of which no details are available); iron ore, 28,090 tons (of this, 36,540 tons of bog ore were manufactured in the Province); phosphate shipped, 9,060 tons.

The important mica production of Quebec was not fully reported. Ochers, ornamental stone, and slates were mined to a moderate extent. The production of feldspar, galena, graphite, and steatite was small.

British Columbia.—Mr. Archibald Dick, Inspector of Mines of British Columbia, has courteously reported to us the coal product of the Province in 1892 as 826,335 tons, of which 64,579 tons were exported. The great veins of rich silver, lead, and copper ores which have been discovered in the Kootenay district are attracting wide attention. With the advent of the railroad from the south this Province will undoubtedly become an important mineral producer. The Canadian Pacific Railway has done practically nothing to induce the investment of capital along its line; but the roads that will be built from the south will carry the mineral wealth of the Province into the United States and will make this an important source of supply for our metallurgical works, especially should the import duty on ores be abolished or reduced.

Alberta, or the Northwest Territory.—The chief mineral product in this Province is coal, and the output of this is increasing quite rapidly since the building of the Alberta Railway, which furnished an outlet in Montana for 38,000 tons in 1892. The coal production of Alberta in 1892 has been reported to us by the several authorities, as follows:

Produced on the lines of the Canadian Pacific Railway, steam coal..........	182,065 tons of 2000 lbs.
" " " " " " anthracite..........	8,273 " " "
By the Alberta Railway and Coal Company..................................	131,000 " " "
H. W. McNeil..	30,000 " " "
Total in 1892..	351,338 tons of 2000 lbs.

The year 1893 will, no doubt, show a still greater increase.

CHINA.

By John A. Church, M.E.

The mineral production of China cannot be given with much certainty. It is certainly larger than Richthofen's estimate after his journeys in 1870–74, and at present is probably about as follows: Anthracite coal, 1,250,000 metric tons; bituminous coal, 2,250,000; iron ores, 1,000,000; iron, 500,000; copper, 500; lead ores, 1000; silver, from 100,000 to 500,000 oz.; gold, from 100,000 to 200,000 oz. Tin and zinc ore are produced, but the quantity is unknown. Richthofen's figures for bituminous coal have been increased by the product of foreign mining in Chihli and the mines of Southern China. There can be little doubt that even these figures are a minimum. Iron ores are estimated on the basis of 55% Fe. The largest production, that of Shansi, 160,000 tons, is from hydrous oxides and carbonates, and this is also the source of iron in many other provinces, even in Kwang-tung, where magnetite, hematite, and limonite, all of fine quality, are available. In general, however, when the Chinese have the choice they prefer magnetite, as in Lian-tung, where the hydrous ores are rejected. The estimate is further based on the estimate of 500,000 metric tons as a minimum for China's product of iron.

Copper is obtained under peculiar conditions. Yunnan province, which has supplied the metal for many centuries and still contains abundant resources, is so situated that a transport of 2000 miles is necessary, partly by men, and partly by small boats, larger boats, and finally steamers. The mines are maintained only by the pride of the Chinese Government, which pays the miners 10 taels, or 8¾c. gold, per lb. When this price was fixed (in 1889) Japanese copper was selling in Chinese ports for about 12½ taels per picul, or 9½c. per lb. The Government therefore paid about double for native copper, for overland freight in China costs above 20c. silver per ton per mile, and an allowance of 12½c. per ton per mile for combined land and water carriage is moderate. In the first quarter of 1891 343 tons of "tribute" copper and 333 tons of "tribute" spelter passed Ichang, a treaty port on the Yang-tse River and the farthest inland of all the treaty ports. This metal was probably derived from the mines of Yunnan and Kwei-chao.

It is impossible to learn whether the Chinese produce any lead. They make lead-silver "bullion" in a few places, but the entire product of lead is eaten up by their wasteful system of cupellation, and by recharging the litharge which is used even with rich roasted galena ores. Eleven hundred tons of the alloy were made in 1888–89 by foreigners in Shan-tung, but as the silver content was only 40 oz. it could not be extracted, because it would not pay to import a foreign cupel for this small quantity. Freights were too high to move it to the only existing cupel furnace in the country, and the Chinese method would use up the lead.

Silver mines under Chinese management are poor affairs. All the known outcrops have been worked out, and the small quantities obtained by robbing pillars make a yield of 3000 to 5000 oz. an ample estimate for each of the best mines. The number of mines is unknown.

The production of silver was estimated in 1838 at about 2,300,000 oz. (memorial to the Emperor), and in 1856 at 700,000 oz. (Otres-Koff). All the silver mines known to foreigners have reduced their output since the latter date, and if the Chinese produce more than 100,000 oz. at the present day the locality of its production is not known.

Until this year the mining of gold in the most promising district of the empire (Manchuria) has been prohibited by law, but in spite of this from $1,500,000 to $2,000,000 worth finds its way to Peking every year. Probably some of it comes from Corea. If the Chinese Government desired to foster mining it is probable that the gold-fields of Manchuria and Corea could take a position of importance in the world's supply, but long-practiced habits of stealing might operate with overwhelming disaster to an industry in which the values are so condensed as in gold-milling.

The net export of gold to foreign countries amounted to $10,398,065 in the four years 1888-91, or an average of nearly $2,600,000 per year. Before 1891 the average was only $2,000,000, but in that year the export rose suddenly to $4,431,895, which shows how rapidly the Manchurian fields may become important under Government encouragement.

Coal.—Richthofen's discovery that China contains a larger store of coal than any other country has often been published. He calculated that, the world's product in 1878 being 300,000,000 tons, the anthracite coal alone of one Chinese province (Shansi) could maintain this output for 2100 years. Shansi has an equal quantity of bituminous coal, and at least ten other provinces contain important stores of coal.

Iron Ores.—Large outcrops of magnetic iron ore are found in Mongolia, where it is titaniferous, and in Kwang-tung (Canton province), Liao-tung, and Shan-tung. I have seen the Mongolian and Canton deposits. The former show immense outcrops, but their titanic acid, about 12%, places them beyond present use. The Canton ores outcrop in several places over a district seven miles long, and the ore has every appearance of purity.

Hematite is found in the Liao-tung, Shansi, Shan-tung, and Canton provinces. Limonites of fine quality, carbonates, and aluminous ores are found in so many places that China's store of iron ores may be said to be comparable to her great supplies of coal.

The existence of these widespread deposits has importance in view of the decision of the Chinese Government to exclude foreign iron and steel in building the main railways. The search for Bessemer ores, however, is likely to be as trying in that country as in others; but if iron rails are used it is probable that the necessary ores can be obtained at some point on almost any line along which it is desired to build. This is certainly true of the Peking-Hankow line, which has been authorized but not begun.

Manganese.—Manganese is found in the Shan-tung and Canton provinces, but the quantity is not known.

Copper and Lead.—So far as known, the copper mines are confined to the southern part of the empire, in Yunnan and Kwei-chao. Lead, silver, gold, and mercury are also found in this region, which for varied resources resembles our own Western mining districts more than any other part of the empire. Silver-mining has been practiced with success in Mongolia, Yunnan, and to a small extent in Shan-tung and Kwang-tung, and lead would be a by-product in all these provinces if the native methods of cupellation were less wasteful.

Gold.—China appears to have an extensive gold-field in Manchuria and Corea, and perhaps also in Yunnan and Kwei-chao. The two former are in the extreme north and the two latter in the extreme south of the empire. It is reported that the northern mines have been thrown open to foreign methods of work, but the oppressive peculiarities of local government will probably prevent the effectual opening of the mines by foreigners.

TRANSPORTATION.

The wretched condition of interior transportation in China prevents the proper utilization of her coal beds. In 1891 the imports of coal were 369,994 tons, and besides this Hongkong, the most active shipping port in China, is said to import 40,000 tons per month from Japan, Australia, and England. Six hundred miles inland from Shanghai the best anthracite is mined and sold in lumps of 60 to 100 lbs. weight for 20c. per ton, and the fine coal is sold at 10c. per ton for local household use. The hindrance which a high freight charge imposes on commerce is shown in the fact that coal mined and sold for an average of 31c. a ton at Shi-pa-tsui sells for $15.30 per ton at Chao-ling-pu, 75 miles distant. This charge of 20c. per ton per mile seems to be the common rate of overland freight in China.

On account of this burden no decided expansion of Chinese mining can be expected unless railroads are introduced. The real fuel of the country is a farm product, the stalks of the tall millet, the grains of which are used for food, for feeding animals, and for distilling. It is probable that a more intimate acquaintance with Chinese trade would lead to some increase of the estimates above given, but there can be little doubt that a balance now exists between production and consumption under existing conditions of freighting. Foreign intercourse has injured native iron-mining, for imported scrap (to the amount of 57,000 tons in 1891) is imported and worked up in the treaty ports and spread through the low country reached by the water-ways which open into these ports.

CHINA.

Year	Imports.											
	Coal.		Copper and Manufactures of.		Iron and Manufactures of.		Lead and Quicksilver.		Tin and Tin Plates.		Kerosene Oil.	
	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Gallons.	$
1880.	217,936	1,355,672	972	347,200	51,830	2,146,200	9,755	1,138,200	3,888	1,472,800	....	579,600
1881.	256,869	1,754,060	1,281	440,860	45,366	1,732,620	17,151	1,653,560	5,788	2,014,020	....	663,300
1882.	257,248	1,683,600	1,443	510,600	45,249	1,771,920	15,434	1,516,620	4,404	2,016,180	....	1,330,320
1883.	245,835	5,559,300	1,153	413,100	49,546	2,003,400	11,989	1,081,350	4,581	2,011,500	....	947,700
1884.	267,695	2,015,550	1,364	499,500	51,126	2,002,050	6,535	6,650,700	4,395	1,659,150	... .	1,115,100
1885.	306,881	2,203,450	2,855	839,470	72,901	2,531,110	9,983	873,760	5,301	2,082,800	....	2,164,080
1886.	316,086	2,176,790	2,799	665,500	65,658	2,127,180	13,283	1,137,400	3,778	1,586,310	23,038,000	2,675,310
1887.	309,534	2,128,230	3,732	884,520	62,003	1,965,600	13,762	1,178,190	3,963	1,641,510	12,015,000	1,597,050
1888.	272,706	1,872,410	2,049	574,040	78,691	2,469,050	14,174	1,316,450	6,513	2,570,750	16,613,000	2,507,470
1889.	376,643	2,686,010	3,296	820,380	69,619	2,345,880	15,837	1,485,950	5,010	2,124,400	20,655,000	3,248,750
1890.	311,044	2,466,250	2,206	646,250	68,141	2,658,750	13,596	1,336,250	5,549	2,378,750	30,829,000	5,116,250

NOTE.—Previous to June, 1887, the returns are exclusive of the trade in native vessels (junks), for which information was not available.

FRANCE.

The Coal Industry.

By Emile Delecroix, Director of "La Revue de Législation des Mines et Statistique des Houillères."

The working of French coal mines during the year 1892 was characterized by a decline in prices and the maintenance of high wages; yet, notwithstanding these unfavorable circumstances, the working of the coal-pits has been remunerative, and has permitted the payment of some dividends to stockholders. The most important fact of the year 1892 was the strike at the mines of Carmaux, brought about by the refusal of the company to reinstate, at the request of the miners, a workman named Calvignac, who was Mayor of the village, and who had been discharged for irregular attendance.

The strike became a political question, and though arbitrated in October—the Prime Minister, M. Loubet, himself acting as arbitrator—the miners refused to accept the verdict, and on Nov. 8 endeavored to blow up the company's office and to kill the president of the company, Baron Reille, with an infernal machine. This machine was found by the office-boy, who took it to the police station, where it exploded and killed six persons.

The statistics for the year 1892 are not yet complete, but the production already known for the first six months of the year, compared with the same period of the preceding years, will enable us to estimate the output for the year, which has not varied much from 26,100,000 metric tons.

PRODUCTION OF COAL AND LIGNITE IN FRANCE.

Year.	Coal, Metric Tons.	Lignite, Metric Tons.	Total Metric Tons.	Year.	Coal, Metric Tons.	Lignite, Metric Tons.	Total Metric Tons.
1889	24,139,406	449,474	24,588,880	1891	25,676,463	523,282	26,199,745
1890	25,592,545	490,573	26,083,118	1892*	12,864,754	243,458	13,108,212

* First six months.

Taken altogether, the coal production increases with regularity, chiefly from the Northern Basin—Pas de Calais. This basin is the continuation of the great coal

zone which begins in Westphalia, goes through Belgium by Liege, Charleroi, Mons, etc., crosses the French border, and thence reaches Auzon, Douai, and Béthune. A slight decrease in production in 1891 was caused by the strikes. This year the basin resumes its progressive course, supplying about 14,000,000 tons of coal. None but the most improved methods of mining are in use, the company at Lens using, for the first time in France, the freezing process for sinking shafts through porous soils.

The importation of coal into France shows that the production, though constantly increasing, is insufficient to supply the demands of the industries, and yet quantities of French coal are exported, principally to Belgium, Italy, Switzerland, and Spain.

VALUE IN MILLIONS OF FRANCS.

(1 franc = 19.3 cents.)

Mineral Imports.	1886.	1887.	1888.	1889.	1890.	1891.
Coal and coke	133.5	136.0	155 8	229.3	269.7	208.3
Copper	30.0	40.3	148.8	23.3	46.5	47.5
Ores of all kinds	33.0	29 6	34.9	37.5	44.2	45.2
Nitrate of soda and potassium	19.4	23.1	38.1	42.1	42.9	38.6
Petroleum and slates	22.5	22.2	26.4	33 7	38.0	36.1
Lead	19.5	21.0	19.1	20.2	22.6	22.7
Iron and steel	15.5	17.3	19.5	15.2	16.8	19.3
Zinc	13.0	14.5	14.0	14.1	16.3	17.5
Tin	14.7	17.5	23.0	14.1	15.3	14.9
Sulphur	7.1	7.3	5.8	6.8	8.8	12.1
Pig-iron	8.6	6.7	7.6	6.8	8.1	8.9

Exports.	1886.	1887.	1888.	1889.	1890.	1891.
Coal and coke	15.9	17.6	22.1	38.8	42.2	31.8
Copper	14.1	19.6	37.2	37.5	43.7	47.5
Pig-iron, iron, steel	19.4	29.5	29.2	43.6	49.0	29.6
Tools and works in metal	92.0	104.2	99.4	112.0	131.0	141.4
Mechanics and machinery	45.1	60.0	58.9	59.8	69.7	70 4
Goldsmith's works	104.5	111.8	100.7	124.2	80.2	69.0
Weapons	9.7	9.8	10.0	5.5	11.4	9.9

The amount of coal supplied by England is still increasing (75,000 tons in 1892), while that from Germany and Belgium is decreasing. Most noteworthy is the increase in the importation of German coke, a syndicate in Westphalia giving enormous facilities to French purchasers.

Coal Trade.—During the year 1892 the coal trade was influenced by a slow but persistent fall of prices. In October and November, at the time for laying in supplies for winter, prices advanced and strengthened the market a little. Glancing at the coal industry in 1892, the insufficiency of the national production is apparent. France consumes nearly 10,000,000 tons of coal more than she produces, and the situation is made still more grave by th fact that the colonies, the navy, the naval stations, etc., are almost exclusively supplied with English coal. A coal syndicate has already been formed at Marseilles, and another is being formed in the Basin du Nord, Pas de Calais. Other districts, on account of their richness, extent, and accessibility, can be largely developed if a channel of exportation through Dunkerque and Calais is created.

The national interest of France demands that the departments bordering on the Channel and the Atlantic Ocean, as well as the colonies and the naval stations, should be supplied with French coal exclusively.

GERMANY.

DURING the year 1892 trade may be said to have been depressed all round. Complaints were everywhere rife of scarcity of orders and unremunerativeness of prices. The cholera also was not without its influence upon the general industry.

The condition of the coal and coke trade in 1892 was not satisfactory, the chief characteristic being the disposition shown by the coal owners to make concessions to secure large contracts. Another feature has been the dissolution of certain syndicates, or combinations, on account of their inability to embrace all the collieries of the district. The contracts, which were frequently concluded at rates much lower than the prices officially quoted by the combination, prove that the non-controlled output was considerable, and that combinations in Germany, as elsewhere, can be readily circumvented. The market opened very weak and continued so throughout the year. The great strike in England, it was thought by some, would raise the price in Germany; but it had, if anything, a contrary effect. In July the market was livelier, but again became dull in August, and still more so in September. As winter approached, however, as is usual, the general coal trade showed a little more firmness, on account of the demand for household coals.

The spelter trade has, on the whole, been satisfactory. The market opened brisk and firm, the works were well engaged, and good orders were received. The syndicates formed by the Silesian firms had the effect of keeping up the price until autumn, when there was a slight fall in value. The price in October was 363@365 marks for ordinary brands and 385 marks for G. von Giesche's W. H. brand.

All the iron markets opened dull and weak, with large quantities of pig-iron stocks on hand. In Upper Silesia the iron trade has not been so depressed for years. In the spring the improvement of the condition of the finished-iron trade reacted favorably on the pig-iron market, but the improvement was not great enough to cause a diminution of stocks. At the close of the third quarter there were 22 furnaces in blast, and this number will scarcely be increased for some time to come, as stocks of pig-iron are still heavy. Rich foreign ores were imported in small quantities, only to mix with the native brown ores; they were obtained principally from Bohemia and Hungary. The importation of Galician ore has almost ceased. In Rhenish Westphalia the market also opened weak for all grades except spiegeleisen, which was in brisk demand. Prices were so low that operations were reduced. In March, owing to active demand both for home consumption and export, there was improved business experienced in nearly every branch of the iron trade, but stocks remained about the same. The latter part of the year showed an improvement, and rates continue steady. The Luxemburg-Lorraine, Siegen, and Nassau districts are in much the same unsatisfactory condition as Rhenish Westphalia. In the Siegen district the total output of 1891

was a little higher than that of 1890, and in the first and second quarters of 1892 no reduction had taken place. The prices, however, were so low that the small mines had to close. In the Lahn district the output of 1891 was smaller than that of 1890, and during 1892 the output was still smaller and of a lower grade.

Copper.—Copper is won in Germany from several ores, the chief being chalcopyrite and copper glance. The pyrites bed in the coal measures of Rammelsberg, near Goslar, in the Hartz Mountains, is a deposit 600 meters long and 80 meters thick, and is composed of copper, pyrites, galena, blende, fahlerz, and iron pyrites, with heavy spar, calc-spar, and quartz. It was first worked under Kaiser Otto I., between 930 and 940 A.D.

The most important source of copper in Germany is Mansfeld, on the southeastern extremities of the Hartz Mountains. The geological formation of this district is exceedingly simple, as, with the exception of an occurrence of metaphyse in the Wepper Valley, the whole region is composed entirely of stratified rocks, of which the "Rothliegendes" forms the lowest member, then the "Zechstein," and uppermost the "Bunter Sandstein," which consists of red clay-slates, red sandstone and shales, oolitic beds, and thick masses of gypsum. The Rothliegendes forms the base of the "Kupferschiefer" (copper shale). The Zechstein formation consists of two principal divisions, the lower comprehending the "Kupferschiefer-Flötz," or cupriferous seam, and the "Dach," or the Zechstein proper; while the upper consists of "Stinkstein," "Asche," and "Rauchwacke," with gypsum and various clays.

The bituminous marl constituting the copper schist, or shale, lies with great regularity on the Rothliegendes. The metalliferous contents of the schist occur as a rule in the form of a "Speise," or very fine particles, which on transverse fracture cause a metallic reflection in sunlight. A golden color shows a predominance of chalcopyrite; a violet, blue, or copper-red color the presence of erubescite; more rarely the color is steel gray from copper glance, and sometimes bluish gray from the presence of galena. The Speise consists principally of sulphuretted ores of copper, but there also occur argentite, blende, galena, and iron pyrites. Although none of the layers of Kupferschiefer are barren, it is only in a few bands that the ore occurs in workable quantities. The thickness of the productive seam varies from 2½ in. to 5 in., and contains from 2% to 3% copper with from 5 to 10 lbs. silver to the ton of copper.

From the report recently issued by the "Mansfeld'schen Kupferschieferbauenden Gewerkschaft" for the year 1891, it appears that the quantity of copper shale mined during the year was 521,696 tons, which included 51,719 tons of "Dachberge" (an inferior quality shale), or a decrease of 14,793 tons from 1890, due to the inability to get rid of the water in the lower levels. They were thus forced to work, and at a greater cost, the higher levels, which are much poorer in both copper and silver. The cost of mining amounted to 38.21 marks (about $9.50) per ton, which was 2.29 marks more than in 1890. The total quantity of ground excavated was 1,533,500 sq. meters, or 102,600 sq. meters less than in the previous year, which makes 2.94 sq. meters to the ton of shale. At present, of a total quantity of 11,562,100 sq. meters of excavated ground, 3,793,700 sq. meters are under water. The furnaces altogether smelted 512,828 tons of shale, against 543,470 tons in 1890. The black-copper production was 39,331 tons, against

40,854 tons in 1890. The yield per ton of shale was 75 kilos black copper. The copper yield, after deducting the copper and silver contents of foreign charges per ton of shale smelted, was 30.45 kilos copper and 0.18 kilo Ag, against 31.25 kilos and 0.182 kilo, respectively, in 1890. The refining works put out 14,466 tons refined copper; besides which there were 164.8 tons from foreign ores, and 734.7 tons electrolytic copper, so that the total copper production was 15,365.5 tons. The product of fine silver was 80,512.26 kilos.

The total German output of copper ore in 1891 was 587,409 tons, of which Mansfeld produced 521,696 tons, or 88.4%; Andreasberg 20,420 tons, or 3.5%; and the other mines in the Hartz 175 tons; so that, if we consider Andreasberg and Mansfeld to be in the Hartz (they are both on its borders), we find that these mountains produce no less than 92.3% of the whole German output.

Lead.—Numerous veins containing argentiferous galena occur in Devonian rocks in the vicinity of Brilon, Müsen, and Siegen, in Rhenish Westphalia. In the sandstones of Bleiberg in the Eiffel, district of Düren, there occur large deposits of lead, in the form of "knotten," or nodules, and the rock to which they belong is known as "knotten-sandstein." The nodules consist chiefly of galena and more rarely of cerussite. They are spherical concretions usually smaller than a pea, and at Bleiberg constitute from 4% to 10% of the whole of the bed. The total production of lead ore in these provinces in 1890 was 82,400 tons, valued at 10,575,343 marks. Of this total the district of Commern-Gemünd (where the Meinerzhagener Bleiberg mine Mechernich is the chief producer) yielded 43,440 tons.

In the Hartz, lead ores occur in the Devonian and Lower Carboniferous rocks of Clausthal and Zellerfeld, in the Devonian rocks of Rammelsberg, and in the Silurian rocks of St. Andreasberg and Haizgerode. The Rammelsberg is a mountain on the northern border of the Hartz. The mineral deposits consist of lenticular masses of ore chiefly composed of zinc blende, copper pyrites, and galena. The production of concentrated ore in the Hartz for 1890 was: Clausthal, 7233 tons; Lautenthal, 1683 tons; Grund, 4635 tons; Andreasberg, 239 tons—total value, 2,953,688 marks, or 205.88 per ton. At Rammelsberg 34,818 tons of crude ore were produced.

In the Erzgebirge the lodes occur in crystalline schists and in igneous rocks. The chief district is Freiberg, where there are about 90 lodes, chiefly in gneiss, both red and gray, which toward the west is overlain by mica schists and clay-slates. The schistose strata are traversed by eruptive rocks, some of which have become converted into serpentine. The output of ore in the Freiberg district for 1891 was 31,502 tons, valued at 4,654,948 marks.

The deposits of Upper Silesia containing zinc and lead are inclosed in beds of the lower "Muschelkalk." Galena occurs in the form of grains or in seamlike deposits in dolomite. The thickness of the beds is not more than four meters. The produce of this Province for 1891 was 27,616 tons.

The production of lead ore in Prussia in 1891 amounted to 140,112 metric tons.

Zinc.—The most important deposits of Germany are those of Upper Silesia, which occur in the beds of the lower "Muschelkalk" and extend from Tarnowitz in a southeasterly direction through Beuthen to Poland. The ores consist partly

of carbonate and silicate of zinc, with compact blende, but principally of zinciferous brown ironstones, "red calamine," and "white calamine," the white generally forming the lower bed and the red the upper. Altogether there were 35 zinc mines in Upper Silesia working in 1890. The total output of zinc ore in Upper Silesia in 1890 was 635,538 tons, of which 58.8% was calamine and 41.2% blende. The average value per ton was: Calamine, 12.45 marks; blende, 35.33 marks.

In the Eiffel limestones (Iserlohn, Arnsberg) there occur irregular fissures filled with calamine and concretions of blende, and similar deposits are found in the Devonian limestone of Altenbühren and in the magnesian limestones of the same age at Gladbach, near Cologne. At Wiesloch, in Baden, there is an important deposit of calamine in the "Muschelkalk." Blende occurs with the lead ores of the Upper Hartz, particularly in the district of Lautenthal, and in connection with the lead and silver ores of Freiberg and with the lead ores of the Holzappel group.

The total German output of zinc ore in 1891 was 793,442 tons, of which Prussia contributed 792,350 tons.

GERMANY.

Years.	Mineral Products Imported.							
	Coal.		Unwrought Copper.		Guano.		Pig Iron.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
1881	1,953,100	3,906,250	11,020	3,719,250	113,950	5,697,500	244,600	3,669,000
1882	2,090,600	6,010,500	10,580	3,596,750	106,300	5,847.250	283,000	4,245,250
1883	2,181,182	5,725,500	11,665	3,791,000	72,985	3,649.250	274,821	3,710,000
1884	2,296,777	6,029,000	13,819	3,973,000	68,271	3,413,500	264,501	3,174,000
1885	2,375,905	6,771.250	13,168	3,127,500	64,408	2,254,250	215,974	2,294,750
1886	2,560,291	7,040.750	11,913	2,531,500	66,599	2,164,500	164,865	1,648,750
1887	2,674,739	7.355,500	12,427	2,734,000	74,049	2,406,500	157,102	1,649,500
1888	3,252,409	9,269,250	8,082	2,929,750	61,610	2,002,250	216,958	2,223.750
1889	4,556,559	15,919,000	29,643	7,262,500	57.758	2,021,500	337,731	4,770.500
1890	4,164,538	15,883,000	31,432	9,272,250	47,996	1,679,750	385,328	5,590,750

Years.	Mineral Products Imported.							
	Machinery.		Metal Wares.		Niter.		Petroleum.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
1881	26,115	4,531,000	43,295	5,992,500	98,121	7,726,750	364,880	14,595,250
1882	31,850	5,543,500	43,850	6,134,500	130,246	8.622,750	342.500	12,416,000
1883	34,502	5,669,000	45,545	6,013,000	170.530	9,618,250	370,500	13,886,500
1884	39,399	6,129,750	51,111	6,178,250	203.535	10.335,500	462.545	17,345.500
1885	37,147	5,776,750	48,056	5,840,000	158,053	7,971.750	482,189	17,479.500
1886	30,935	4,711,250	44.497	5,445,750	182,595	8,298,250	438,395	14,247,750
1887	35,045	5,457,500	56,730	5,875,500	200,906	9.371,250	509,399	15,282,000
1888	42,697	6,621,500	51,513	6,504,750	272.990	13,747,750	564,172	21,156,500
1889	45.790	8,011.250	70,344	7,964.750	333 117	15,839,750	625,668	20,334.250
1890	56.843	10,463,000	89,395	9,899,250	344,299	13.777,250	646,804	18.272,250

Years.	Mineral Products Exported.									
	Coal.		Glass & Glasswares.		Pig Iron.		Iron Manufactures.		Pig Lead.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
1881	7,458,250	13,052,000	64.940	8,145.500	245,495	4,603,000	388,665	21,312,000	46,800	3,393,000
1882	7,631,600	14,309,250	69.400	9,546,000	186.950	3.505,000	327,500	33,459,250	41,900	2.829,250
1883	8,705,000	15,233,750	79,269	9,514.750	258,461	4,329,250	333,190	32,977,000	49,574	3,098.250
1884	8,816.935	15.429,500	84,051	8,852,750	230,008	3,047,500	308,355	32,528,250	49,313	2.650.500
1885	8,955,629	20,150,250	81,757	8,081,750	213,534	2,349.000	339,094	25.479,250	41.123	2,210.250
1886	8,655.240	19.907,000	84,209	8,448,500	250,681	2,694,750	335,213	22.675,000	38,771	2,423.250
1887	8,781,377	19.977,750	94,446	9,375,750	212,293	2,547,500	365,492	25.686,000	39,108	2,395,250
1888	9,460.258	23.414.250	97,702	10,176,000	144,251	1,659,000	331,720	29,791,250	34,890	2,355,000
1889	8,847,202	23.856.750	78.138	9.164,500	156,435	2 346,500	317,591	29,389,250	32,780	2.110.250
1890	9,145.187	28,895,500	88,961	10,679,750	116.922	1.917,000	350,123	30.309.000	32.124	2,128,250

MINERAL PRODUCTION OF GERMANY.

Metric ton = 2204 lbs. 4 marks = $1.

	1878.		1879.		1880.		1881.		1882.		1883.		1884.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
MINERAL.														
Coal	39,589,778	51,978,922	42,025,687	51,425,857	46,973,566	61,416,229	48,688,161	63,062,962	52,118,595	66,964,844	55,943,004	73,407,112	57,233,875	74,695,048
Lignite	10,930,120	8,614,782	11,445,029	8,806,726	12,144,469	9,177,503	12,852,324	9,530,548	13,259,616	9,038,892	14,499,644	9,751,747	14,879,945	9,894,586
Graphite	1,255	28,910	992	28,035	1,450	38,338	1,510	32,921	2,161	52,774	2,945	49,192	1,925	22,925
Asphaltum	47,329	179,806	45,430	98,654	50,072	112,415	42,330	89,184	37,120	63,107	42,930	65,185	41,139	57,913
Petroleum	845	18,166	1,895	38,285	1,309	39,858	4,108	131,446	8,158	187,669	3,755	87,895	6,490	137,789
Rock salt	202,939	340,672	238,160	397,695	272,270	451,284	311,907	490,254	322,442	526,974	336,400	522,474	344,797	484,984
Kainit	32,742	147,359	49,891	173,772	137,425	441,394	160,538	542,184	141,272	508,009	230,071	777,422	203,120	722,401
Other Potash Salts	737,470	1,464,681	611,781	1,354,619	528,424	1,254,397	745,353	1,801,001	1,060,120	2,410,216	959,292	2,135,490	766,076	1,888,805
Epsomite	520	1,299	765	1,907	2,144	4,391	4,625	9,545	8,130	18,078	4,850	10,890	4,917	10,894
Boracite	52	4,105	104	9,012	99	12,081	124	21,412	118	22,627	199	26,987	166	27,781
Iron ore	5,462,059	6,579,154	5,869,439	6,673,104	7,238,639	8,613,373	7,600,800	9,090,154	8,263,254	9,795,415	8,756,617	9,829,677	9,005,796	9,385,779
Zinc ore	597,193	2,855,779	589,546	2,012,441	632,895	2,982,584	659,530	2,398,603	694,711	2,978,018	677,794	2,222,606	632,040	1,954,843
Lead ore	152,843	5,265,788	149,055	4,460,674	159,725	4,780,454	164,771	4,810,084	177,655	5,155,235	169,754	4,522,714	162,772	3,934,914
Copper ore	373,539	2,141,392	398,828	2,518,456	480,853	2,998,892	523,697	3,582,474	566,509	3,6[illegible]0,150	613,211	4,017,330	593,330	4,536,724
Silver and Gold ore	15,446	847,390	22,314	977,088	20,578	952,916	26,787	1,068,859	22,977	1,082,811	25,302	1,100,116	25,186	1,204,740
Tin ore	137	26,871	147	32,432	200	43,428	164	57,573	158	54,868	139	38,108	185	42,825
Quicksilver ore	....	....	14	101	29	175	....	....	....	....	....	....	....	....
Cobalt, Nickel, and Bismuth ore	264	125,529	406	130,444	424	117,822	266	126,938	323	137,646	399	138,464	476	132,897
Antimony ore	189	10,414	72	4,655	96	5,173	77	4,175	75	1,998	37	1,129	25	1,136
Arsenic ore	2,031	12,507	640	15,682	727	10,784	867	11,357	480	7,171	275	3,966	1,240	20,431
Manganese ore	6,000	67,506	6,748	67,866	11,889	119,895	13,642	117,672	6,735	66,523	6,488	53,679	9,672	66,996
Uranium and Wolfram ore	30	2,245	29	2,079	38	2,614	48	5,809	63	9,307	57	9,223	43	10,084
Iron Pyrites	101,089	327,414	100,537	274,026	112,287	291,038	125,057	319,841	158,419	451,405	149,521	340,071	150,130	325,310
Other Vitriol and Alum ores	34,803	25,809	20,652	13,794	21,768	11,065	21,018	12,358	23,742	10,953	13,198	10,283	13,813	8,132
Totals	58,288,673	81,066,500	61,568,161	79,517,394	68,791,376	93,878,103	71,947,704	97,317,354	76,872,833	103,224,690	82,435,882	109,121,760	84,077,158	109,567,937
METALLURGICAL:														
Pig-iron	2,147,641	28,645,564	2,226,587	28,088,021	2,729,038	40,847,595	2,913,009	40,993,670	3,380,806	48,977,102	3,469,718	46,245,998	3,600,618	43,159,979
Zinc	94,953	7,951,628	96,756	7,456,223	99,646	8,467,684	105,478	7,913,484	113,418	8,987,492	116,854	8,432,436	125,276	8,525,624
Pig lead	79,482	6,410,750	82,362	5,719,216	85,928	6,353,854	86,729	6,006,923	92,591	6,297,897	90,732	5,481,875	94,809	5,054,490
Litharge	5,046	388,577	4,605	288,338	3,923	274,517	4,514	302,686	4,432	293,869	5,291	311,834	4,919	256,956
Copper (pig)	9,322	3,219,048	10,051	3,053,581	14,252	4,766,756	15,273	5,046,557	16,290	5,656,813	17,936	6,095,912	18,750	5,658,268
Copper (matte & black)	268	36,934	560	53,229	989	73,363	1,079	104,286	886	78,884	545	46,996	300	25,981
Silver, kilos	167,660	6,347,583	177,507	6,629,531	186,010	7,151,890	186,990	7,128,520	214,982	8,190,764	235,063	8,771,974	248,116	9,263,965
Gold, kilos	378	264,084	467	325,599	463	322,938	381	265,641	376	262,789	457	319,578	556	387,714
Tin	83	26,871	93	34,324	104	44,965	106	60,794	102	54,365	99	46,837	96	40,038
Sulphuric Acid	110,753	1,680,092	135,106	1,944,970	156,052	2,121,795	258,626	3,335,984	286,953	3,576,686	297,437	3,594,929	345,139	3,696,801
Copper Sulphate	4,388	388,568	4,801	403,768	4,728	471,684	4,804	444,284	4,663	430,806	5,132	525,139	6,040	623,859
Unenumerated	5,875	870,461	7,910	1,005,039	9,764	1,082,588	14,821	1,219,621	14,276	1,276,609	14,481	1,243,569	15,205	1,216,877
Total tons	2,457,811	56,230,160	2,568,831	55,001,839	3,104,424	71,979,629	3,404,439	72,822,450	3,914,417	84,034,076	4,018,225	81,117,077	4,211,152	77,910,552
Total kilos	168,038		177,974		186,473		187,374		215,358		235,520		248,672	

MINERAL PRODUCTION OF GERMANY.—*Continued.*

Metric ton = 2204 lbs. 4 marks = $1.

	1885.		1886.		1887.		1888.		1889.		1890.		1891.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
MINERAL.														
Coal	58,320,398	75,735,539	58,056,598	75,181,924	60,333,984	77,769,327	65,386,120	85,265,832	67,342,171	96,269,970	70,237,808	134,511,033	73,715,653	147,379,551
Lignite	15,355,117	10,094,458	15,625,986	10,055,566	15,898,634	10,050,345	16,573,963	10,224,096	17,631,059	11,087,328	19,053,026	12,442,209	20,536,625	13,541,457
Graphite	3,359	40,128	2,906	30,425	2,960	46,585	3,353	46,925	3,347	43,122	4,355	73,921	3,824	73,540
Asphaltum	45,412	64,037	42,894	54,018	31,483	46,531	41,534	63,812	43,496	81,311	51,144	94,497	49,150	93,928
Petroleum	5,815	117,654	10,385	240,386	10,444	233,280	11,920	256,973	9,591	220,290	15,226	310,508	15,315	298,659
Rock salt	377,491	488,806	444,397	537,664	405,420	465,516	414,557	453,937	544,591	563,704	557,060	618,301	666,793	744,754
Kainit	242,281	929,641	240,421	880,753	239,412	852,254	318,576	1,166,666	324,477	1,181,655	361,827	1,299,939	472,256	1,701,640
Other Potash Salts	678,662	1,852,766	704,849	1,938,058	840,691	2,359,260	916,759	2,561,931	861,273	2,601,592	913,030	2,826,199	898,993	2,771,494
Epsomite	4,207	9,409	13,850	28,301	23,235	44,565	13,269	26,198	10,951	21,237	8,030	17,449	7,454	16,314
Boracite	140	16,782	144	13,043	153	15,267	180	14,367	121	9,059	182	13,710	177	12,660
Iron ore	9,157,869	8,478,355	8,485,758	7,410,853	9,351,106	8,501,318	10,664,308	9,940,280	11,002,188	11,617,129	11,406,132	11,957,255	10,657,521	9,852,076
Zinc ore	680,654	1,911,852	705,177	1,930,502	900,712	2,505,524	667,761	3,436,753	708,829	4,422,495	759,437	5,853,998	793,544	6,238,384
Lead ore	157,869	3,773,304	158,505	3,979,656	157,570	3,980,810	161,777	4,170,963	169,569	4,432,581	168,234	4,524,580	159,215	4,163,988
Copper ore	621,381	4,813,628	495,756	3,603,835	507,587	3,637,928	530,956	4,379,758	573,290	4,549,752	596,100	5,041,683	587,626	5,216,192
Silver and Gold ore	24,561	1,070,469	21,230	1,119,605	25,726	1,044,430	20,390	1,017,150	22,264	1,010,433	21,360	1,146,000	22,569	1,151,723
Tin ore	196	47,419	131	41,662	126	41,250	152	45,700	120	32,817	102	29,267	75	22,839
Quicksilver ore	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cobalt, Nickel, and Bismuth ore	617	134,092	344	121,385	319	135,868	339	145,269	793	125,059	976	159,338	1,074	159,328
Antimony ore	5	393	2	176	2	170	2	110	1	62	1	75	1	41
Arsenic ore	1,824	28,996	1,140	16.513	323	4,972	1,521	20,484	2,668	30,855	2,655	32,058	3,124	32,563
Manganese ore	16,628	104,757	27,050	203,837	38,385	255,731	28,710	167,037	45,167	236,793	41,841	196,379	40,335	202,445
Uranium and Wolfram ore	31	9,877	48	22,002	33	16,549	42	9,345	45	13,618	42	9,274	47	10,564
Iron Pyrites	116,212	239,660	113,656	224,795	101,136	192,824	109,516	212,129	117,366	222,653	122,372	251,939	128,288	239,468
Other Vitriol and Alum ores	7,207	4,889	2,523	1,876	550	1,156	515	1,181	696	1,496	1,379	1,921	2,406	1,517
Totals	85,817,936	109,968,914	85,153,750	107,636,835	88,872,991	112,201,460	95,866,220	123,676,896	99,414,053	138,775,011	104,322,319	181,411,533	108,762,065	193,925,125
METALLURGICAL:														
Pig-iron	3,687,434	40,236,629	3,528,658	35,566,527	4,023,953	41,610,652	4,337,121	47,830.067	4,524.558	54,342,633	4,658,451	66,894,961	4,631,218	58,107,003
Zinc	129,098	8,465,042	130,854	8.630,291	130,494	9,149,352	133,224	10,905,920	135.974	12,333,655	139,266	15,598,177	139,353	15,639,337
Pig lead	93,134	4,853,097	92,520	5,525,189	94,921	5,623.797	96,995	6,211,947	100,601	6,372,531	101,781	6,407,359	95,615	5,816,587
Litharge	4.186	214,775	3,876	223,954	4,446	260,897	4.571	290,721	3,924	255.367	3,972	264,071	3,124	197,317
Copper (pig)	20,628	5,209,638	20,021	4,326,517	20,848	4,542,999	21,569	7,884,699	24,597	7,027,161	24,455	7,228,966	24.302	7,011,268
Copper (matte & black)	343	22,339	423	27,005	416	43,228	1.010	88.550	263	25,267	793	66,026	596	46,139
Silver, kilos	309,418	11,034,448	319,598	10,676,887	367,633	12,039,502	406,603	12,869,059	403,037	12,703,182	402,945	14,037,716	444.852	14,749,420
Gold, kilos	1,378	963,728	1,065	743,584	2,251	1,570.370	1,793	1,250.953	1,958	1,366,377	1,855	1,290,417	3,077	2,141,998
Tin	107	48,681	79	42,877	66	36,905	84	46,680	63	30,096	64	30,887	237	131,131
Sulphuric Acid	343,295	3,367,051	352,723	3,166.579	382.894	3,181,430	398,797	3,368,392	429,739	3,531,244	464,044	3,828.918	467,633	4,018,746
Copper Sulphate	5,410	471,566	4,712	337,189	4,797	318,716	4.416	357,604	4,818	504,698	5.854	624,757	3,502	288,938
Unenumerated	14,609	1,229,480	15,075	1,346,330	16,423	1,447,801	19,086	1,349,919	19,535	1,670,522	19,839	1,816,790	21,805	2,088,133
Total tons	4,298,244	76,116,474	4,148,941	70,612,929	4,679,258	79,825,649	5,016,873	92,454,511	5,244,072	100,162,733	5,418.519	118,089,045	5,317,435	110,236,017
Total kilos	310,796		320.663		369,884		408,396		404,995		404.800		447,929	

MINERAL PRODUCTION IN PRUSSIA.

(In coal, brine salt, kainit, other potash salts, iron ore, zinc ore, lead ore, and copper ore 1 = 1000.)

Mineral.	1888.		1889.				1890.				1891.			
	Metric Tons.	$	Metric Tons.	$	Per Cent Increase.		Metric Tons	$	Per Cent Increase.		Metric Tons.	$	Per Cent Increase.	
					Tons.	Val.			Tons.	Val.			Tons.	Val.
Anthracite coal	59,475	72,979	61,436	83.145	3.3	13.9	64,373	119,880	4.8	44.2	67,528	131,806	4.8	9.5
Brown coal	13,207	8.039	14,205	8,832	7.5	9.9	15,468	9,967	8.9	12.8	16,739	10,892	7.5	9.2
Asphalt..	10,747	25,348	12,310	41,805	14.5	64.9	14,533	50,079	18.2	20.2	11,217	36,021	−23.0	−28.6
Petroleum.....	2,770	98,441	3,059	104,495	10.4	6 2	2,249	84,545	−26.5	−19.0	2,498	76,050	11.1	− 7.1
Rock salt	188,692	235,914	251,849	286,308	33.3	21.8	250,351	303,066	− 0.6	6.0	283,924	321,893	13.4	6.2
Brine salt	268	1,410	268	1,589	.....	12.7	271	1,721	1.0	8.3	365	1,675	34.5	− 2.7
Kainit..........	258	934	280	1,011	8.7	8.3	309	1,096	10.2	8.3	399	1,422	29.4	30.3
Other potash salts...... ...	723	1,845	689	1,832	− 4.7	− .7	708	1,938	2.8	5.9	618	1,713	−12.8	−11.6
Magnesium salts..........	11,152	21,900	8,959	17,047	−20.	−22.2	6,688	14,311	−26.0	−16.1	6,420	13,896	− 4.0	− 2.9
Boracite.......	148	12,149	111	8,350	−25.	−31.2	176	13,260	59.0	59.0	150	11,074	−14.7	−15.1
Iron ore	4,145	6,385	4,375	7,856	5.5	23.2	4,243	7,900	− 3.3	0.56	3,903	6,207	− 8.0	−21.3
Zinc ore........	667	3,432	708	4,414	6.2	28.6	758	5,844	7.1	26.0	792	6,231	4.5	6.6
Lead ore.	143	4,024	149	4,243	3.8	5.5	149	4,350	−0.10	8.3	140	4.001	− 5.7	− 8.0
Copper ore	522	4,310	564	4,467	8.0	3.7	588	4,979	4.2	11.4	578	4,147	− 1.6	3.4
Gold and silver ore...........	63	10,306	77	7,851	22.2	−24.0	152	13,569	100	73 0	131	20,610	−14.0	52.6
Cobalt ore	33	992	503	2,739	1422	176	651	10,739	29.4	292	575	9,210	−11.6	−14.3
Nickel ore	9	336	17	872	100	159	33	409	100	−53.2	185	1,452	460	255
Arsenic ores ..	1,198	18,098	1,882	26,080	57	22.7	2,183	27,728	16.1	6.3	2,169	25,864	− 0.6	− 6.6
Manganese ores	27,308	153,386	44,006	225,397	61.3	47.0	40,131	181,696	− 8.7	−19.3	36.859	181,900	− 8.1	0.1
Pyrite..........	99,305	186,533	107,955	195,405	8.7	4.8	111,292	216,961	31.2	11.1	119,100	213,460	7.1	− 1.6
Other vitriol & alum ores, etc	211	304	343	494	62.5	62.5	911	649	166	31.2	2,162	963	137	50.0

Amber.

There are but few substances, of natural or artificial origin, to which cling so much of romance and mystery as this fossil gum. Noticed first by Homer (Od., xv. 460) as an article of great value among the Phœnician traders, more than 1200 years before Christ, it continued down to the time of Pliny, A.D. 23–79, to be invested with mysterious powers supposed to be derived from supernatural sources. Pliny was the first to speak of its real nature,—i.e., a vegetable gum,—but he was by no means free from the current superstitions concerning it, for he held that amber beads worn as a collar would protect infants from poison, witchcraft, and sorcery.

Among the Oriental nations its antiseptic and prophylactic powers are still highly cherished, and they consider it the best material for the mouthpieces of pipes. Since very early days it has been derived almost entirely from the southern shores of the Baltic, some, however, being obtained in the northern part of Burmah. The Emperor Nero sent an expedition from Rome to the Baltic Sea, and 13,000 lbs. of amber were secured and brought back, a single piece weighing 13 lbs.

It occurs along the Baltic coast in deposits of varying thickness, stratification, and value. Occasionally it is picked up along the Danish and Swedish coasts, and on the east coast of England. The Sicilian amber obtained from near Catania is most beautiful, exhibiting plays of color and purple lights that greatly

enhance its attractiveness. It has been found also near Basle, in Switzerland, and in France, particularly in the Departments of Aisne, Bas Rhin, Gard, and Loire. In England it has been found in the London clay, and in the United States in New Jersey, Maryland, and North Carolina.

But with the exception of the Burmah deposits, which are worked irregularly and have an indefinite value, the only commercial source of amber are the Baltic mines. Here it is found in close association with mineralized wood underneath a covering of sand and clay that in places is 40 and 50 ft. deep. The amber is found in rounded or stalactitic pieces, with pyrite and sulphate of iron. Some of the excavations are 100 ft. deep, but there seems to be little regularity in the course of the lead. The richest deposits are between Memel and Königsberg, and at other points along the coast. Here the amber-bearing deposit is about three feet thick, and is mined as any other similar stratum. It is obtained also by dredging and diving, and is picked up along the shore after heavy storms. Of recent years the greater amount has been obtained by mining, the product of the dredgers and the divers having shown for some years past a steady decline.

For the following table we are indebted to Messrs. Stantien & Becker, Königsberg, Prussia. It embodies information that has not been available hitherto, and shows the annual production of all kinds of amber from 1885 to the close of 1891, with the number of men employed in the various operations. The value of crude amber varies greatly, according to the purity and color, so that no general statement can be given beyond saying that the average value is about $3 per lb.

AMBER.

Year.	Steam Dredging.		Mines.		Diving.		Scrap.	No. of Men Sorting.	Total.	
	No. of Men.	Quantity, Metric Tons.	No. of Men.	Quantity, Metric Tons.	No. of Men.	Quantity, Metric Tons.	Quantity, Metric Tons.		No. of Men.	Quantity, Metric Tons.
1885	850	67.00	700	108.00	100	4.75	3.75	....	1,650	183.50
1886	820	46.50	430	97.50	100	5.00	4.00	....	1,350	153.00
1887	700	22.50	550	125.00	100	4.00	6.00	....	1,350	157.50
1888	700	50.00	650	122.50	100	2.50	5.00	....	1,450	180.00
1889	750	57.00	650	153.00	100	2.50	4.00	130	1,630	216.50
1890	500	50.00	650	145.00	100	2.50	4.00	290	1,540	201.50
1891	None	None	700	150.00	100	60	4.00	350	1,150	154.60

ITALY.

THE principal mineral product of Italy is brimstone, mined in Sicily, the value of which amounts annually to about one half the total mineral output of the country. The products next in importance are zinc and lead ores ; the latter are reduced in the country, but the former are entirely exported. Practically the whole of the brimstone output is also sent out of the country, which has been for many years, and still is, the most important source of the world's supply of this valuable mineral.

The United States is a large consumer of Sicilian brimstone ; the amount of its imports, prices, etc., will be found under the captions "Sulphur" and "Pyrites." The crude mineral exported to the United States is divided into seven grades, the difference between any two being no more than 30c. per ton. Cataina, Licata, and Girgenti are the ports of export. Brimstone is refined in Sicily at Catania only.

The development of the metallurgical industry in Italy is checked by the lack of cheap coal, as nothing but lignite of very inferior quality is produced in the country. Hence the total supply has to be imported from foreign mines.

The statistics of Italian mineral production, imports and exports, are given in the following table :

Years.	Mineral Products Imported.							
	Coal and Coke.		Iron in Bars, First Fusion.		Machinery, Locomotives, and Parts.		Railway Materials : Wheels.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1880	1,738,000	11,469,200	62,008	3,383,600	18,216	5,196,000	58,617	3,048,000
1881	2,073,315	12,440,000	84,034	4,162,400	23,089	6,200,800	72,872	2,842,000
1882	2,180,020	12,208,200	87,407	3,750.200	30,386	7,768.400	133,267	4,797,600
1883	2,351,000	13,166,200	106.088	4,312,000	32,416	7,981,200	118,574	3,557,200
1884	2,605,000	13,546,200	113,943	4,161,000	32,749	8,021,200	98,801	2,865,200
1885	2,957,000	14,195,600	123,854	4,130,800	35,839	8,749.400	103,113	3,031,600
1886	2,927,000	13,464,600	154,002	4,684,000	32,739	7,447,000	51,900	1,318,200
1887	3,583,000	16,482,400	219,842	6,036.200	42,108	9,549,400	67,156	1,719,200
1888	3,873,000	17,815,400	119,741	4,027,600	35,928	7,920,800	33,934	848,400
1889	3,999,000	21,595,200	109,460	4,569,200	36,909	8,711,600	9,889	296,600
1890	4,355.000	24,387,200	71,817	3,504,200	31,452	7,882,800	4,870	160,800

Years.	Mineral Products Exported.					
	Marble, Alabaster, and Manufactures.		Sulphur, Raw and Refined.		Zinc Ore.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1880	109,074	3,035,600	287,149	6,719,200	85,300	1,108,800
1881	97,441	3,151,200	289,365	6,713,200	70,872	850,400
1882	110,618	3,345,000	273,347	6,123,000	102.359	1,228,400
1883	116,642	4,730,600	288,381	6,056,000	106,378	1,276,600
1884	114,480	4,391,400	277,210	5,267,000	89,563	1,074,800
1885	111,766	3,855,200	289.257	5,206,600	103,472	1,283,000
1886	108.154	3.335,000	300,881	4,994,600	82,134	1,149,800
1887	110.092	2,689,200	279,628	4,194,400	82,541	1.238.200
1888	105.806	2.609,600	323,790	4,630,200	90,074	1,801,600
1889	125,187	3,192,800	331,902	4,646,600	107,066	2.248.400
1890	127,133	3,034.000	328,708	5,259,400	80,759	2,099,800

MINERAL AND METALLURGICAL PRODUCTIONS OF ITALY.

Metric tons = 2204 lbs. 5 lire = $1.

	1885.		1886.		1887.		1888.		1889.		1890.		1891.	
	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.	Metric Tons.	Dollars.
MINERAL.														
Iron ore	200,955	425,057	209,082	458,491	230,575	505,530	177,157	399,866	173,489	377,446	220,702	483,203	216,486	553,437
Manganese ore	1,802	11,294	5,561	32,065	4,434	22,665	3,630	15,600	2,203	10,360	2,147	10,414	2,429	12,919
Copper ore	27,236	317,151	25,162	220,013	43,826	243,878	47,088	324,367	48,214	268,306	50,378	371,541	53,059	565,866
Zinc ore	107,887	1,311,827	107,548	1,382,392	93,143	1,251,412	87,310	1,431,888	97,059	1,651,555	110,926	2,450,530	120,685	2,544,121
Lead ore	40,184	1,155,182	39,841	1,425,673	38,221	1,387,590	35,178	1,382,012	36,894	1,412,469	32,187	1,301,539	30,233	1,196,846
Mixed ore	1,550	16,480	932	2,575	104	1,040	....	....	....	....	....	....	....	....
Silver ore	1,485	392,478	1,639	288,280	1,892	434,729	2,005	384,684	1,997	349,733	1,750	420,195	2,006	394,697
Gold ore	11,106	99,691	10,759	106,530	11,134	116,984	10,638	97,632	10,932	101,685	8,296	104,320	7,729	93,275
Antimony ore	2,887	80,195	1,738	39,991	848	21,166	507	13,249	563	20,014	891	65,742	782	64,643
Iron pyrites	11,372	32,008	17,149	30,446	18,470	37,165	14,633	29,532	17,022	49,299	14,755	37,719	19,868	54,117
Lignite, etc	190,413	301,560	243,325	360,750	327,665	500,572	366,794	534,515	390,320	571,631	376,326	581,254	289,286	441,170
Sulphur	425,547	6,992,826	374,343	5,592,456	342,215	4,738,839	376,538	5,002,603	371,494	4,930,575	369,239	5,653,058	395,528	8,905,091
Rock salt	17,204	61,558	18,394	60,263	18,788	56,185	18,424	56,327	18,475	57,298	17,098	51,660	31,285	75,890
Asphaltum and Bitumen	13,728	61,356	17,943	77,650	18,507	83,984	20,064	101,022	29,844	108,206	45,125	240,778	28,180	135,780
Petroleum	270	22,013	219	18,226	208	15,344	174	11,126	177	10,200	417	24,121	1,155	68,420
Mineral waters	....	....	....	....	....	....	2,100	5,260	3,500	5,700	3,580	5,940	3,586	5,667
Alum, rock	6,000	36,000	6,000	36,000	6,000	6,000	6,050	6,050	5,600	28,000	5,000	5,500	4,000	3,840
Graphite	4,000	36,000	4,000	32,000	1,572	3,419	1,390	2,889	1,531	2,144	1,735	4,656	2,415	6,593
Total	....	11,372,676	....	10,163,801	....	9,425,902	....	9,798,622	....	9,954,622	....	11,812,170	....	15,122,372
METALLURGICAL.														
Pig-iron	15,991	319,820	12,291	245,820	12,265	220,950	12,538	284,440	13,473	424,619	14,346	425,784	11,930	315,209
Iron, wrought	140,734	5,629,360	161,633	6,465,320	172,834	9,443,840	176,769	8,285,571	181,623	10,068,667	176,374	9,729,727	152,668	7,996,458
Steel	6,370	382,200	23,760	1,425,600	73,262		117,785	5,601,293	157,899	7,031,167	107,676	5,821,482	75,925	3,948,765
Lead	16,461	987,660	19,508	1,287,528	17,795	1,100.000	17,481	1,180.000	18,165	1,035,250	17,768	1,137,152	18,500	1,139,600
Silver	kg. 33,346	934,056	kg. 33,839	1,082,348	kg. 33,387	1,100,000	kg. 34,891	1,098,254	kg. 33,565	1,005,150	kg. 34,248	1,164,432	37,600	1,203,200
Gold	" 209	125,688	" 195	105,547	" 234	126,985	" 187	101,[illegible]65	" 216	113,969	" 206	108,836	284	166.839
Copper and alloys	1,651	676,789	2,239	700,555	3,197	970,839	5,332	2,113,665	6,904	2,449,200	6,406	2,404,366	5,977	2,243,228
Quicksilver	237	175,500	251	185,973	244	204,587	339	338,615	385	454,890	449	583,994	330	356,400
Antimony	240	41,560	198	27,986	22	2,818	....	....	197	56,013	182	54,716	218	37,714
Common salt	410,255	....	353,852	....	391,548	861,406	382,593	841,705	420,625	529,789	448,827	916.757	....	....
Salt from springs	10,678	57,625	10,881	62.301	10,412	59,170	11,325	78,095	10,015	54,029	9,879	67,799	9.258	53,389
Alum	2,950	83,200	5,320	39,960	2,260	57,500	1,380	31.541	1,380	30,120	1,294	26,276	1,029	20,080
Sulphate of Alumina	630	12,800	440	8,160	1,980	34,000	2,825	43,722	2.667	61,048	2,553	58,430	859	17,168
Sulphur	....	....	....	....	74,686	1,448,571	74,474	1,417,083	{ 53,316 54,105	991,727 1,077,214	50,537	1,011,108	....	....
Asphaltum and Bitumen	....	....	....	....	....	....	....	....	....	....	57,115	1,245,071	....	....
Petroleum	....	....	....	....	....	....	....	....	....	....	10,302	80,594	....	....
Boracic acid	....	....	....	....	....	....	....	....	....	....	350	42,000	....	....
	1,761	190,188	3,063	306,280	2,879	305,163	2,603	260,270	2,473	247,310	2,824	301,424	3,831	444,780
Briquettes, coal	....	....	....	....	408,414	2,252,017	490,349	2,662,254	506,700	3,068,680	559,300	3,363,640	....	....
" charcoal	....	....	....	....	12,600	203,200	11,900	209,190	13,750	234,500	16,750	301,100	....	....
Total	....	9,616,446	....	11,943,878	....	18,751,046	....	24,547,963	....	28,923,332	....	28,844,688	....	....

Japan.

The Ashio copper mines and works * are now in the hands of Mr. Furakawa of Tokio, who pays a royalty to the Government. Since coming into his possession the production of the mines and smelting-works has largely increased and now amounts to 600 tons of black copper a month, all of which is refined at Tokio. The mines are worked by adits; the vein of copper sulphide is 3 to 4 ft. thick, the central 6 in. of which carries 20% copper.

The method of treatment is as follows: The rich ore culled at the mine is sent to the concentrating works, there to be resorted and crushed. The poor ore is crushed and concentrated by jiggers and buddles of American manufacture, and also by hand-washing in wooden bowls, for which women are paid 7c. per day. It is claimed that washing by hand is cheaper and more thorough than that by machines, but it is impracticable from its limited capacity.

By concentration the poor ore is brought up to about the same grade as the rich ore. An analysis of a picked sample ran: Copper, 21.15; iron, 23.49; sulphur, 27.14; alumina, 0.79; lime, 0.24; magnesia, 0.04; silver, 0.01; silica, etc., 27.14—total, 100. The average ore contains appreciable quantities of arsenic and tin, with traces of bismuth.

After concentration the ore is removed to the smelting-works, half a mile away. It is roasted in ordinary brick reverberatory furnaces 108 ft. long by 9 ft. broad, fired with wood, top heat only being used. Six tons of charge are passed through and drawn in twelve hours. The ore is not sufficiently roasted and still contains 10 to 12% of sulphur, which causes much trouble in the subsequent operations. The capacity of the roasters should be increased.

The smelting-plant consists of six rectangular wrought-iron water-jacket furnaces, the jackets at the tuyères being 60 by 30 in. These furnaces are now made in the foundry and fitting shops at Ashio. The blast is supplied by six Root blowers carried into one main air-pipe; the fuel is charcoal mixed with a little coke, which costs \$16 per ton, against \$8 for charcoal. Limestone flux is obtained in the neighborhood. Water-jacket hands receive 35c. per day.

The amount of ore and roasted matte passed through each furnace daily is about 40 tons. Black copper with a considerable amount of matte is obtained, assaying about 55%. The black copper analyzes: Copper, 96.014; arsenic, 1.226; iron, 1.361; tin, 0.692; lead, 0.428; sulphur, 0.337; bismuth, 0.112; silver, 0.014; cobalt, 0.012—total, 100.196.

The slag is run into the river Waterasagawa, close by, and assays 0.7% copper. The matte is broken up, heap-roasted imperfectly, and again put through the water-jackets. Open-air stalls built of slag blocks are being introduced. Mr. Kimura, the manager, is also erecting a bessemerizing plant for the matte, by which it is expected that it will be at once converted into a fine black copper, free from impurities. Mr. Menzies doubts this result. A more complete roasting of the ore might have avoided the necessity for this plant.

An unlimited supply of timber producing an excellent charcoal is found close by. The river supplies water for the furnaces and concentrating works, and a

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* Condensed from a paper by W. J. Menzies in the *Engineering and Mining Journal*, August 6, 1892.

flume from the river several miles above the smelter furnishes 200 horse-power for electric-lighting purposes, driving motors, etc.

The total number of hands employed is 10,000, including charcoal-burners, mule-drivers, tramway hands, etc.. Cheap labor, with proximity to ore, limestone, and fuel, permits of a moderately low cost of production. The output is being constantly extended, and is largely exported to the Chinese market, where it comes in competition with European copper.

MINERAL PRODUCTION OF JAPAN IN 1890.

Name of Product.	Weight. Metric Tons.	Value. Yen = $0.82.	Name of Product.	Weight. Metric Tons.	Value. Yen = $0.82.
Gold .... oz.	23,401	$405,167	Iron .... tons	4,887	$119,830
Silver .... "	1,701,903	1,716,601	Steel .... "	1,173	36,383
Copper .... tons	17,972	4,180,107	Pyrites .... "	225	431
Copper vitriol. .... "	27	2,680	Copperas .... "	940	12,350
Lead .... "	769	59,466	Coal .... "	2,608,284	5,111,603
Tin .... "	47	19,198	Sulphur .... "	26,353	247,299
Antimony .... "	3,173	358,092	Graphite .... "	4,529	11,652
Arsenic .... "	111	1,365	Petroleum ....gals.	2,017,116	181,612
Ores of Manganese .... "	2,571	7,650			
Pig Iron .... "	16,176	253,510	Total	....	$12,724,996

RUSSIA.

The mineral industry of Russia has been in a depressed condition for the past few years, owing to the bad crops. During 1889 and 1890 there was very little water in the large rivers, and intercommunication was rendered difficult and expensive. Following this there was a heavy drop in the rate of exchange, and new purchases were therefore limited in amount.

In 1890 there were 172 establishments in the empire devoted to the production of pig-iron, 146 to cast-iron, and 32 to steel. Cast-iron was consumed for Government and other manufactures in the following amounts: Shells, made in seven Government factories, 723 tons;* iron wares, 4727; manufactures of iron and steel, 111,983; steel shells, 700; cannon stands, 200; nails, 22,356; ships, 1372; iron wire, 22,749.

The production of clay for porcelain in 1889 amounted to 4521 tons. Cobalt was produced in the Caucasus in 1890 to the amount of 14.69 tons. The amount of coke manufactured in 1890 was 295,571 tons. The production of glauber's salt was 3267 tons, against 10,177 in 1889. The amount of iron ore mined in 1890 was 1,793,416 tons, in addition to which 2367 tons of chrome-iron ore were mined in the Ural. The production of petroleum in 1889 was 3,306,814 tons, and in 1890, 3,974,531.

Phosphate rock is found in many parts of Russia, but at present is mined in but three Governments. The production in 1890 was 12,896 tons; of pyrites, 17,125 tons were mined in that year.

Quicksilver is found in the Government of Ekaterinoslav, and there in only one place; the production in kilograms from 1887 to 1890, both years inclusive, was as follows: 1887, 63,984; 1888, 164,614; 1889, 166,905; 1890, 291,781. The production of silver in 1889 was 95,241 kilograms; in 1890, 160,835. The production of tin in 1890 amounted to 13,153 kilograms.

Complete statistics of the gold and silver in Russia are to be found under the caption of "Gold and Silver." In obtaining the product in 1890 there were 82,108 men employed. The silver product from lead ores in that year was derived from 74 mines. The entire silver product from both silver and silver-lead ores for 1889 and 1890 was obtained from four districts, viz., Siberia, the Kirghese steppes,

* The weights used are the metric system tons of 2204.6 English lbs.

the Turgaï region, and the Caucasus. The production of ores in metric tons is given in the following table:

Year.	Siberia.	Kirghese Steppes.	Turgai Region.	Caucasus.	Total.
1889.....	24,224	1,881	49	4,784	30,938
1890.. ..	23,503	1,494	65	4,747	29,809

New argentiferous lead mines were opened in 1890 in Kapatschai and Kuban. This district covers an area of 80 square miles, and embraces 44 veins, traversing a country-rock of porphyry, granite, and metamorphic schist. The lead obtained yields from one half to three per cent of its weight in silver. The imports and exports of gold and silver coin and bullion during 1891 were as follows, the figures being stated in kilograms:

Metal.	Imports.		Exports.	
	Coin.	Bullion.	Coin.	Bullion.
Gold....	77,759	14,254	561	3 4
Silver..........	35,158	214,299	7,951	81,063.0

The coinage of the St. Petersburg Mint, to which all the gold and silver of the empire must be brought, is given in the following table, all classes of coin being reported at their value in silver rubles. A ruble, at the United States coining rate, is equivalent to $0.7718.

Coin.	1886.	1887.	1888.	1889.	1890.
Gold....................	27,055,175	25,510,095	24,430,030	28,150,090	3.735.140
Silver (rubles)	510,551	500,022	1,753	76,760	500,024
Silver, subsidiary	1,000,002	1,000,011	2,000,001	2,000,003	2,351.504
Copper..	100,000	100,000	100,000	200,003	200.000.5

The following tables give the principal Russian imports and exports for ten years and the native production and consumption of the principal mineral substances, together with a percentage of the total consumption which is supplied by domestic mines.

CONSUMPTION OF PRINCIPAL MINERAL PRODUCTS IN RUSSIA, AND PROPORTION FURNISHED BY DOMESTIC MINES.

Year.	Coal.		Copper.		Iron.		Iron (Cast).		Salt.		Steel.	
	Tons.*	Per cent.	Tons.*	Per cent.	Tons.*	Per cent.	Tons.*	Per cent.	Tons.*	Per cent.	Tons.*	Per cent.
1881......	5,260,551	66.3	12,317	28.1	399,390	73.0	698,914	67.0	1,019,791	81.2	522,816	56.0
1882......	5,447,305	69.1	3,304	108.6	399,228	74 3	670,404	69.1	1,837,397	90.6	404,993	60.6
1883......	6,132,003	64.7	7,711	56.4	425,936	75.6.	718,187	66.9	1,289,764	88.1	226,611	97.7
1884......	5,764,874	68.0	10,589	57.0	459,279	78.0	795,617	64.0	1,103,581	92.0	214,331	96.0
1885......	5,999,844	71.0	8,176	57.0	440,652	82.0	726,992	72.0	1,156,680	97.8	198,847	96.0
1886......	6,318,375	72.0	6,552	69.6	433,556	81.0	795,996	66.0	1,205,401	99.8	252,706	95.0
1887......	5,946,626	76.1	5,641	88.3	418,268	88.2	740,454	82.6	1,155,707	99.7	232,607	96.8
1888......	6,739,176	76.8	5,122	89.7	426,460	85.4	741,094	89.9	1,116,168	99.5	231.562	95.8
1889......	8,059,570	77.0	8,663	55.3	508,565	84.0	855,680	86.3	1,407,205	98.4	274,347	94.2
1890......	7,534,331	79.7	10,030	57.0	524,153	82.5	1,051,367	88.1	1,398,134	99.3	394,631	95.7

* Metric tons, converted from poods; one pood = 16.36 kilos.

RUSSIA: IMPORTS AND EXPORTS OF MINERAL PRODUCTS.

Year.	Imports.							
	Cement and Clays.		Coal and Coke.		Pig-iron.		Iron Manufactures.	
	Tons.*	Value.	Tons.*	Value.	Tons.*	Value.	Tons.*	Value.
1880......	135,386	$2,367,750	1,922,373	$13,555,850	244,054	$6,972,350	193,658	$24,871,770
1881......	81,525	775,390	1,791,378	11,358,270	234,319	7,084,524	116,661	18,398,380
1882......	96,868	1,296,680	1,730,721	11,918,060	219,071	7,435,890	114,589	11,079,530
1883	112,131	1,467,620	2,267,377	13,965,490	237,557	7,412,020	109,885	11,557,700
1884......	116,459	2,252,250	1,914,098	12,285,350	284,098	8,657,110	85,410	9,099,860
1885......	96,410	1,540,770	1,827,901	11,897,270	221,459	6,721,330	67,967	7,496,720
1886......	91,148	1,134,980	1,860,115	10,362,660	237,869	6,323,240	74,295	8,560,860
1887......	107,230	1,231,230	1,569,016	8,711,780	144,016	4,268,110	55,475	5,861,240
1888......	93,607	980,210	1,728,787	9,979,200	74,443	1,924,230	62,705	7,034,720
1889......	87,377	972,510	2,070,934	11,651,640	104,311	3,032,260	88,082	9,254,630
1890......	114,590	1,096,480	1,739,705	9,570,330	124,082	3,726,030	94,295	9,442,510

Year.	Imports.									Exports.	
	Rails.		Lead.		Metal Wares.	Petroleum.		Salt.		Unwrought Metals.	
	Tons.*	Value.	Tons.*	Value.	Value.	Tons.*	Value.	Tons.*	Value.	Tons.*	Value.
1880..	4,632	$368,060	16,546	$2,270,730	$14,157,990	23,698	$3,135,440	148,521	$4,743,970	137,154	$6,412,560
1881..	955	118,900	18,219	2,215,290	19,124,490	19,888	2,962,190	186,374	5,489,330	3,524	629,090
1882..	904	120,120	15,711	1,791,790	22,858,990	17,161	2,129,820	168,701	5,139,750	7.896	2,433.200
1883..	639	83,930	18,410	1,841,070	17,276,490	7,525	944,020	155,246	4,506,040	3.077	787,710
1884..	180	23,100	18,148	1,801,800	15,714,930	4,525	568,260	87,377	2,497,880	3,197	937,860
1885..	607	36,190	10,951	1,334,410	11,325,160	2,328	299,530	43,410	862,400	3,180	1,646,260
1886..	377	45,430	13,311	1,411,410	12,539,450	672	98,560	23,066	485,870	3,344	1,454,530
1887..	98	7,700	17,639	1,864,170	9,146,060	246	43,120	14,541	225,610	3,295	1,544,620
1888..	148	16,940	18,787	2,046,660	10,589,040	197	42,350	11,574	175,560	1,164	1,211,980
1889..	230	25,410	19,328	2,361,590	11,261,250	230	38,500	23,033	324,170	1,689	1,571,570
1890..	721	74,690	20,705	2,381,610	8,954,990	131	23,870	17,213	222,530	2,180	1,717,870

* Metric tons, converted from poods; one pood = 16.36 kilos.

MINERAL PRODUCTION OF RUSSIA.

Year	Coal, Tons.	Copper,* Tons.	Gold,† Kilos.	Iron, Tons.	Cast-iron, Tons.	Lead Tons	Manganese Ore, Tons.	Platinum, Kilos.	Silver, Kilos.	Spelter, Tons.	Steel, Tons.	Salt, Tons.
1881	3,488,901	3,460	36,763	291,854	467,905	985	11,224	2,981	9,423	4,542	292,964	830,013
1882	3,765,957	3,587	36,152	296,963	461,962	571	14,412	4,077	8,000	4,462	247,267	1,664,950
1883	3,972,192	4,350	35,735	322,411	481,097	542	17,029	3,520	7,362	3,809	221.612	1,136,566
1884	3,925,107	6,211	35,677	361,787	508,897	631	18,180	2,233	9,652	4,313	226,911	1,022,521
1885	4,623.056	4.715	33,019	261,838	526,882	714	60,458	2,587	11,239	4,579	192,659	1,131,791
1886	4,570,869	4,515	33,439	362,559	344,475	776	74,313	4,310	13,251	4,190	241,495	1,194,359
1887	4,528,104	4,983	34,865	368,949	611,388	988	58,135	4,502	15,362	3,621	225.204	1.155.280
1888	5,179,478	4,597	35,166	364,095	666,108	798	32,640	2,713	15,116	3,869	222,017	1,111,679
1889	6,206,166	4,793	37,258	427,263	739,149	577	77,937	2,632	13,840	3,681	258,418	1,392,599
1890	6,007,457	5,718	39,371	432,649	925,322	836	182,346	2,841	14,544	3.768	377,961	1,388,365

* Refined. † Unrefined.

The gold product for 1892 amounted to 30,500,000 metallic rubles, which is equivalent to $23,539,900 or 35,419 kilos of refined gold. The silver product for 1892 was 711,000 metallic rubles, worth at U. S. coining value $548,749 and weighing 13,204 kilos.

Russian Poland.—The production of coal in Russian Poland in 1891 amounted to 2,561,995 metric tons from 15 collieries, as compared with 2,419,283 tons produced in 1890 from 14 collieries. In 1890 the output per workman was 254 tons, and in 1891 only 226 tons; in that year there were employed 3,373 miners, 6,858 helpers, 1,102 women, and 116 children—total, 11,449 persons.

SOUTH AMERICA.

By Charles Bullman, M.E.

South America, during the three hundred years following its discovery in 1492, contributed probably nearly 90% of the world's production of gold and silver during that period, and though its relative importance has greatly declined since the commencement of the present century, owing partly to its own lessened output and partly to the increased production of other countries, it is still a very important source of supply and one that is capable of vast and indefinite expansion. It is not, however, as a producer of the precious metals alone that South America commands a prominent place in the mineral industry, for in the production of copper, guano, platinum, precious stones, and other important articles it is worthy of the large space devoted to it in this volume.

MINERAL EXPORTS OF THE ARGENTINE REPUBLIC.

	1888.*		1889.†		1890.‡	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Bismuth	39.5	$158,288	78.1	$275,485	6.8	$23,800
Borate of lime	....	....	....	....	64.3	5,365
Borax	110.0	6,600	121.2	7,959	148.2	8,683
Copper bars	115.7	46,308	56.4	22,556	102.4	40,957
Copper ores	348.6	82,665	167.5	45,237	87.5	23,615
Gold	....	....	.007	4,277	....	.... ..
Gold ore (sand)	444.4	75,549	202.1	34,355	37.6	6,392
Guano	92.2	2,765	550.0	16,500	47.0	1,507
Lead	....	....	31.8	2,549	11.3	1,135
Lead ore	124.6	9,970	110.0	8,800	93.2	7,452
Silver (bullion)	18.35	679,024	19.0	703,814	6.1	243,960
Silver ore	370.4	183,238	177.6	88,995	264.1	132,071
Tin	342.8	171,705	353.5	176,733	110.0	55,020
Total	....	$1,528,822	....	$1,645,606	....	$675,197

* *American Consular Report No.* 115.
† *American Consular Report No.* 124.
‡ *American Consular Report No.* 138.

Bolivia.

This country is especially notable for the number and richness of its silver-mines, chief among which are those of Huanchaca, Aullagas, and Colquechaca. Far superior to these, however, was the old district of El Cerro Rico de Potosi, which all authorities agree has been the greatest producer of silver in the history of the world. These mines were discovered in 1545, a few years after the Spanish conquest, and were almost continuously worked up to the outbreak of the war for independence in 1809.

In 1609 the Fondo process for the treatment of sulphide ores was discovered. In 1621 there were 136 reduction-works at the mines, but a few years later they were closed on account of a Spanish war, and remained closed for ten years. In 1693 the production of the mines began to fall off, owing to the exhaustion of the "pacos," or oxidized surface ores, and the number of reduction-works gradually decreased, until in 1759 there were but 55, which number still further decreased to 35 in 1799. From their discovery to 1739 the mines paid a tax of 20% in kind to the Spanish Government on the silver produced, but this was reduced in the latter year to 10%.

In 1759 a report was presented to the King of Spain by the Miners' Corporation, in which it was stated that the veins varied in width from a knife edge to several yards, that the workings had reached many hundred yards in depth, that water and want of air were impeding the working of the deepest mines, and that adits and shafts were so numerous that they were understood by no one.

In 1790 the king employed Baron von Nordenpflicht, a Saxon engineer, to examine the mines. This engineer recommended the continuation of the Royal Socavon (tunnel), but the work was not prosecuted successfully. In 1809, upon the outbreak of the war of independence, the mines were abandoned. In 1825 an English company sent out machinery to work the mines, but the financial troubles of 1826 caused the abandonment of the undertaking. In 1886 Mr. Arthur F. Wendt of New York was sent to examine the property, and after three years' work discovered and reopened the old Cotamitos vein. At present the mines of Cerro Potosi are producing about 400,000 oz. of silver per year.

Humboldt estimates the total production of the Potosi mines as follows: From 1545 to 1555, 2,871,512 kilos = $119,340,000; 1555 to 1789, 17,985,114 kilos = $747,614,337; 1555 to 1600, 3,015,302 kilos = $125,315,951; 1789 to 1803, 1,035,126 kilos = $5,759,836; to which he adds one fourth for silver exported fraudulently, making a grand total of 1,569,758,500 pesos, equal to 33,422,000 kilos, or $1,389,018,320 of silver. Humboldt also estimates a yearly production of 2200 marcos, or 17,600 oz. of gold, which would amount, for the period 1556 to 1803, to 4,382,400 Spanish ounces, equal to 126,201 kilos = $5,244,914.

Danson estimates the production of Bolivia from 1803 to 1848 as follows:

	Silver.	Pesos.*	Kilos.	
1804–1808	16,573,695 pesos + ⅓ fraudulent exports,	22,098,393	497,270	$20,666,541
1809–1826	34,888.641 " + ⅕ " "	41,866,369	942,088	39,153,177
1827–1848	42,789,026 " + ⅓ " "	57,052,034	1,283,800	53,354,728
		121,016,796	2,723,158	$113,174,446

* The peso weighs 25 grams and is 900 fine.

He estimates the gold at 24,011,410 pesos. Dr. Soetbeer estimates the production of the Potosi mines as follows:

PRODUCTION OF EL CERRO RICO DE POTOSI.

Period.	Pesos.	Kilos.	Dollars.	Period.	Pesos.	Kilos.	Dollars.
1545-1555....	86,000,000	1,935,194	80,426,663	1701-1710...	21,800,000	490,500	20,385,180
1556-1560....	34,110,000	767,552	31,899,461	1711-1720...	16,700,000	375,750	15,616,170
1561-1570....	77,600,000	1,746,174	72,570,991	1721-1730...	16,200,000	364,500	15,148,620
1571-1580....	96,000,000	2,160,216	89,778,577	1731-1740...	18,700,000	420,750	17,486,370
1581-1590...	97,100,000	2,184,970	90.807,353	1741-1750...	20,200,000	454,500	18,889,020
1591-1600....	102,300,000	2,401,980	99,826,288	1751-1760...	27,100,000	609,750	25,412,100
1601-1610....	85,900,000	1,932,943	80,333,111	1761-1770...	31,000,000	697,500	28,988,100
1611-1620....	75,600,000	1,701,000	70,693.560	1771-1780...	29,900,000	672,750	27,959,490
1621-1630....	69,700,000	1,568,250	65,176,470	1781-1790...	40,900,000	904,500	37,611,020
1631-1640....	68,400,000	1,539,000	63,960,840	1791-1800...	58,200,000	1,309,500	54,412,820
1641-1650....	59,100,000	1,329,750	55,264,410	1801-1810...	39,600,000	891,000	37,029,996
1651-1660....	50,100,000	1,127,250	46,848,510	1811-1820...	20,200,000	454,500	18,889,020
1661-1670....	40,000,000	900,000	37,404,000	1821-1830...	17,300,000	389,250	16,177,230
1671-1680 ...	38,900,000	875,250	36,375,390	1831-1840...	25,000,000	562.500	23,377,500
1681-1690....	42,800,000	963,000	40,022,280	1841-1850...	27,100,000	609,750	25,412,100
1691-1700....	31,100,000	699,750	29,081,610				

Total, 1.465,710,000 pesos.

At present the largest silver producer in Bolivia is the *Compañia de Minas* de Huanchaca, which since its formation in 1877 has produced bullion to the value of $43,033,899 and paid $14,168,038 in dividends. During 1891 this company mined 31,083 tons of ore, of which 15,818 tons, containing 124,115 kilos of silver, were exported, and 15,265 tons, containing 58,108 kilos, were treated at the Huanchaca reduction-works. Some years ago this company began the erection of extensive reduction-works at Antofagasta, Chile, which, when completed, will be the best of the kind in South America. The system of treatment will be that known as the Tina method of amalgamation. When completed, the plant will consist of six crushers and four sets of rolls, which will feed 10 batteries of 10 stamps each; 43 furnaces of different types, besides 5 for drying the ore and salt; 30 copper pans of two tons' capacity; 15 settling tanks, 12 retorting furnaces, 2 cupellation furnaces, and 2 silver-refining furnaces. According to the last annual report of the company, the ore reserves now in sight are calculated to contain 1,053,637 kilograms of silver, worth, at the United States coining ratio of 16 to 1 with gold, $43,789,153.

Concerning the mines of Colquechaca and Oruro, Messrs. E. E. Olcott and Robert Peele, Jr., write under date of December, 1892, as follows:

"*Colquechaca.*—Hitherto this important group of silver mines has suffered from lack of transportation facilities, but the Antofagasta Railroad has been recently extended north from Uyuni to Oruro, passes between 90 and 100 miles from Colquechaca, and a wagon road has been completed to the station at Challapata. During the past year the principal mines of the group have been consolidated under one management, with great mutual benefit. The consolidated mines are: Los Amigos, Compañia Colquechaca, Flamenca, Porvenir, Consuelo, and Carmen Oriental, the first five of which have all been heavy producers. The main workings of the group are on the Embudo vein, which has been opened to a depth of 1750 feet below the outcrop. From 1868 to January 1, 1892, the mines included in the consolidation produced about $29,000,000 of silver. Good work has been done under the new management during the past

year, and the deepest levels show no diminution in richness. Other mines in the immediate neighborhood are: San Miguel, Gallofa, Consolidada, Huainacuchu, and Gran Poder. San Miguel contains very rich ore, and has been recently reopened.

"*Oruro.*—The principal silver mines, Socabon de la Virgen, San José, Itos, and Atocha, form one group, on several veins, close to the town. During the past 15 years the first two of these mines have been large producers. In 1890 and 1891 the monthly production of silver was from 75,000 to 100,000 oz., nearly one half being profit. By far the greater part of this amount comes from the Socabon de la Virgen and San José. The greatest depth reached is about 1150 ft. Some tin is associated with the silver ore of these mines, but it is small in amount, and considered a by-product. The completion of the railroad will greatly benefit the district."

According to Mr. Anderson, United States Minister to Bolivia, the total production of silver in 1890 was 1,309,174 marcos (301,112 kilos), $1,674,215, of which 637,909 marcos (146,720 kilos) were exported in ore carrying from 50 marcos* per cajon to 400 marcos per cajon—that is, from 123 oz. to 1064 oz. per ton.

Bullion (*plata piña*) produced in the country from low-grade ores 552,166 marcos, and silver used in the arts and clandestinely exported, 119,016 marcos. For total production of gold and silver since the Spanish conquest, see "Gold and Silver,"

Copper.—The only copper mines now worked in Bolivia are those of Coro-Coro and Chacarilla, situated about 40 miles apart, near the Desaguadero River, which flows into Lake Titicaca. According to Messrs. Olcott and Peele: "The Peruvian Corporation of English bondholders is taking steps to deepen the channel of the river in order to open water communication of about 200 miles to Puno, on the lake; thence by rail to the port of Mollendo the distance is 325 miles. At present the mines are not doing well on account of inefficient methods and lack of proper machinery, as well as the low price of copper. The product is about 6000 tons per year of 'barrilla' (concentrates), carrying 66% copper."

Tin.—Of the tin mines of Bolivia, Messrs. Olcott and Peele write as follows in December, 1892: "The tin mines of the Oruro district lie in a north and south belt, and include the following, from 50 miles northeast to 50 miles southeast of the town: Colquiri, Morococala, Negro-Pabellon, Huanuni, Challa-Apacheta, Llallagua, and Abicaya. Berenguela is another group, 75 miles east of Oruro. These mines have up to the present time been worked in a desultory way and with small success, owing to the high cost of transportation. Most of the carefully sorted ore has been shipped out by llamas, via Tacna and Arica, a distance of 250 miles. But large quantities of workable ore exist in the district, and the new railroad is beginning already to cause the introduction of machinery and more efficient methods of mining. The district also contains deposits of antimony and bismuth of good quality. Other tin mines are being worked to the southeast of Huanchaca, producing a high grade of pig-tin. The total production of tin is about 250 tons per month, most of it going to England.

* The marco contains 8 Spanish ounces, and 4.3478 marcos = 1 kilo. The cajon contains 3 tons of 2000 lbs.

"*Silver and Tin.*—The Potosi silver mines, which have produced so much in times past, are now doing but little. The Socabon Real mine has been worked for several years by a French company, and is the only one operated on a scale of any importance. It has a stamp-mill and modern reduction works, and produces a small monthly profit. All the other old mines of the famous cerro are either abandoned or are being worked irregularly in a small way, yielding some silver and a rather poor grade of tin. The two metals occur in the same veins, both being of low grade, and requiring careful sorting.

"The Porco group of mines, 30 miles southwest of Potosi, containing silver and tin, are now almost idle, but it is reported that negotiations are in progress which may lead to a sale to a foreign company. There is a large amount of development, though little work has been done for some years. These mines are among the oldest in Bolivia, having been operated by the Incas previous to the time of the Spaniards, and were large producers when Potosi was discovered."

Complete statistics of the mineral production of Bolivia are not obtainable, as the Government does not publish reports upon either its production or its exports. The country has no seaport, and the greater part, if not all, of its mineral exports are shipped from Peruvian or Chilean ports. The following table shows the exports via Peru for the years 1886 to 1890 inclusive, as given in the *Memoria de Hacienda* of Peru in 1891.

BOLIVIAN MINERAL EXPORTS VIA PERUVIAN PORTS.

Year.	Copper Bars.		Copper Concentrates.*		Gold Dust.		Silver Retorted.		Silver in Ores.		Tin Bars.		Tin Concentrates.	
	Tons.	Value.	Tons.	Value.	Kilos.	Value.	Kilos.	Value.	Kilos.	Value.	Tons.	Value.	Tons.	Value
1886	.. ..	....	....	....	20.87	$13,068	850.0	$36,950	84.2	$1,830	8.13	$2,438	17.98	$3,236
1887	2.2	$859	1,785.0	$321,309	24.62	15,408	5,125.8	222,820	3,893.7	84,630	18.86	5,659	73.37	13,207
1888	33 0	16,428	1,632.4	293,832	22.22	13,914	2,122.8	73,831	704.2	15,656	66.18	19.855	202.08	36,375
1889	46.6	18,636	2,400.1	432,023	39.60	24,786	3,688.8	128,272	1,218.8	26,490	121.49	36,449	240.21	43,238
1890	.9	368	2,385.5	429,406	7.65	5,100	293.8	8,051	†183.0	54.650	24.05	7,215	397.93	....

* These concentrates carry about 66% Cu. † Metric tons ore; at the same time there were exported 105 tons argentiferous lead, valued at $45,977.

NOTE.—Besides the above there were exported in 1886 about 20.2 kilos of old silver plate and 41,291 bolivianos of the value of $35,289, and in 1887 about 50 kilos of plate and 121,367 bolivianos, valued at $103,171. In 1889 and 1890 there were exported 470 kilos of sulphur, valued at $27, and in 1890 about 284 kilos of bismuth, valued at $14.20.

According to the records of the Chilean custom-house at Antofagasta, during 1889 and 1890 there were shipped from that port 361.6 tons of Bolivian tin, valued at $54,242, and 91.6 tons of Bolivian bismuth, worth $684,430.

According to information furnished by the Bureau of American Republics, the exportation of tin from Bolivia since 1880 has been as follows: 1880, 300 tons; 1882, 350 tons; 1884, 400 tons; 1886, 300 tons; 1888, 1000 tons; 1890, 1800 tons.

NOTE.—During 1892 the Huanchaca Mining Company produced 204,000 kilos of fine silver, of which 65,000 kilos were smelted at the works and 139,000 kilos exported in ore. The Playa Blanca Works at Antofagasta have been completed and will shortly be running on ore.

Brazil.

Brazil is noted not only for the enormous yield of its gold mines, but also for certain peculiar geological and chemical conditions under which the gold occurs. Thus, on the coast, and not far south of the equator, gold is found in glacial drift; in the Gongo Soco it occurs alloyed with palladium, and grains of platinum are found in the same vein; at Porpéz it occurs with rhodium, and at Ouro Preto with bismuth.

According to the estimates of Dr. Soetbeer, Brazil ranks fourth among the gold-producing countries of the world, the output from 1690 to 1875 having reached a total of 1,056,053 kilos, worth $701,852,823.

Gold was discovered in Brazil in 1577, but no systematic attempts to mine it were made until the discovery of the placers of Jaragua, in San Paulo, near the close of the seventeenth century. Later the placers of Goyaz and Matto Grosso were opened (1694–1710), and in 1727 the mines of Minas Novas, in Minas Geraes. At the beginning of the eighteenth century the production was about 2750 kilos per annum, but it rapidly increased, reaching its maximum in 1760 with an output of 14,600 kilos, since which time it has decreased, until now it is not more than 700 kilos per annum.

Auriferous veins were discovered shortly after the opening of the placers, but it was not until a full century later that they began to be worked. In 1830 an English company, called the São João d'El Rei Mining Company, leased the mine of that name, which had been profitably worked for a number of years, but abandoned it four years later to work the Morro Velho mine, which has since become famous for its great yield.

Official reports from 1837 to 1865 show a total production of 27,355 kilos of fine gold, valued at $18,180,133. From 1865 to 1892 the company produced about 32,000 kilos, worth $21,257,200, making a total yield of $39,437,000, of which between $6,000,000 and $7,000,000 has been paid in dividends. Up to 1880 the ore averaged $10 per ton. At the present time the only two vein mines in Brazil of much importance are the Maquiné, owned by the Don Pedro North Del Rey Mining Company,* and the Ouro Preto.

During the first eight months of 1892 the Maquiné mine produced 1712 oz. of gold and the Ouro Preto 6032. The latter mine also produced some bismuth.

According to Hartt, the formations affording the most gold are clay-slates traversed by auriferous quartz lodes; *itacolumite,* which is also veined with auriferous quartz; and certain iron ores known as *itabirite* and *jacutinga,* all of which are of Lower Silurian age. The mines of Morro Velho, Gongo Soco, and Ouro Preto are of this class.

Gold is also found in the eozoic gneiss of the coast and of the Mucury Basin; but with the exception of the Rio Bruscus mine in Parahyba, no mine has been

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* According to Hartt, the Maquiné and Morro Velho are the only gold mines in Brazil which have paid. It is to be remarked, however, that the Gongo Soco during the 30 years that it was worked produced gold worth $6,942,080, of which $1,775,815 was profit.

opened in this formation. The gold of the placers of Jaragua and Cantagallo, and in fact of all the alluvial deposits of the coast belt, come from quartz lenses in the gneiss.

Silver.—This metal is found with all the gold of Brazil; the bullion of the Morro Velho mine contains at least 20%.

It is said that a vein of silver ore was discovered by Alfonso Sardinha at Ipanêma in 1578, and that the Government worked it for a number of years, but no record exists of its production. For the years 1885, 1886, and 1887 the Director of the United States Mint reports Brazil as having produced 2640, 141, and 141 kilos of silver, respectively, but since that time none has been reported.

Diamonds.—Diamonds were discovered at Tejuco, now known as Diamantina, in Minas Geraes, in 1746, and at Jacobina, in Bahia, in 1755. The diamonds are found both in old river gravels and in the beds of rivers in whose bottoms numerous pot-holes are found. At San Juan de Chapada the diamonds occur embedded in clay traversing itacolumite and itabirite (a hydro-mica schist containing specular iron). At Corrego diamonds have been found in solid conglomerate. At Tibagy they are found in ancient and recent alluvion, and appear to have been derived from a Devonian sandstone. In 1772 the Government began to work the mines, but the cost was too great, and in 1832 the monopoly was abolished. Exact statistics of the production of these gems in Brazil are not obtainable, and recourse is had to the estimates of various well-informed writers. According to Streeter, Minas Geraes produced, from 1746 to 1850, about 5,844,000 carats, worth $45,000,000, to which he adds $10,000,000 for the contraband trade, making a total of $55,000,000. The same authority gives the output of the Bahia district up to 1850 at 932,400 carats, and estimates the entire production of Brazil up to 1850 at 10,000,000 carats, worth about $70,000,000.

According to Castelnau, the total output up to 1849 was worth $60,000,000. From 1850 to 1860 no statistics are obtainable, but from 1861 to 1867 the yield in carats was as follows: 1861, 81,898; 1862, 87,531; 1863, 101,570; 1864, 85,775; 1865, 86,527; 1866, 98,430; 1867, 99,477. Total value for the seven years, $9,400,000.

Since this year the production has rapidly dwindled, and at present does not amount to over 15,000 carats per year, worth about $100,000. The rich placers of Diamantina and of the Ouro and Paraguay rivers became exhausted about 1840; the laws prohibiting the introduction of new slaves and providing for the gradual emancipation of the old ones caused a scarcity of cheap labor, without which the mines could not be worked; the financial crisis of 1858 in Brazil caused an immense falling off in the value of diamonds, which in turn caused the abandonment of many mines; and the discovery of the great diamond mines in South Africa ruined the market for the smaller stones of Brazil.

A writer in the *Engineering and Mining Journal*, Feb. 23, 1889, estimated the total production of Brazil up to that date at $96,000,000, which would correspond to an output of 12,000,000 carats.

Carbonado.—This substance, also known as *carbonate* and *carbon*, was discovered at Chapada, Brazil, in 1845. It is an allotropic form of carbon, closely related to the diamond, and is found in small irregular crypto-crystalline masses of a dark-gray or black color. Although its density is not so great as the

diamond, it is very much harder; in fact, it is the hardest substance known. It is found in small quantities in Borneo, but has not yet been discovered in the diamond fields of India or of South Africa. At first it was used only in cutting diamonds, but since the invention of the core-drill for boring in rocks it has found a greatly extended use, and is now exclusively employed for the so-called "diamond crown" of this drill. In 1850 it was worth only 25c. per carat, and the demand was limited; but at present it is worth about $14 per carat, and the production has increased to 20,000 carats per annum.

Coal.—The coal-fields of Brazil were discovered by Dr. Perigot of Long Island, U. S. A., in 1841, and were worked at Arroio dos Ratos as early as 1858. The quantity mined was small, and it sold for from $6 to $8 per ton. The most important deposits are in the Province of Rio Grande do Sul and are three in number, namely, that of Jaguarão and Candiota, that of São Sepé, and that of Jacuahy, and all are of true Carboniferous age. The first named has an area of 50 by 30 miles, and comprises four beds, of 3, 11, 17, and 25-ft. thickness, respectively.

According to W. G. Ginty, of the Rio Janeiro Gas-works, this coal greatly resembles Newcastle coal, and gives 60% to 62% of coke and 6900 to 8200 cu. ft. of gas. At São Sepé there are two beds, one 14 and the other 7 ft. in thickness. Its area is small, about 15 square miles, and the overlying sandstones have been faulted and overflowed by trachyte eruptions.

At Jacuahy there is a bed of good bituminous coal six feet thick, which is being extensively mined. These three basins are separated from one another by rolling hills of syenite.

The present annual production of coal amounts to about 50,000 metric tons.

Iron.—The iron mines of Ipanêma were discovered in 1578, but no attempt was made to work them until 1810, when the Prince Regent sent to Sweden for a company of miners, who set up four forges. These failed, and in 1815 new furnaces were built; later still, Palma, the superintendent, erected two furnaces eight meters high, which are still standing. In 1870 these furnaces produced 3000 kilos of pig-iron per 24 hours, wood being the fuel, and a mixture of limestone and diorite the flux. In 1887 there were five small charcoal-iron furnaces in Minas Geraes, producing about 3000 tons per annum, and two furnaces in San Paulo, producing 790 tons.

Phillips describes the Minas Geraes deposits of iron ore as varying from one to four yards in thickness, and extending over a great area. This ore is known as *canga,* and consists of angular fragments of magnetite, iron shale, and brown ironstone, with small quantities of quartzite and itacolumite.

Copper and manganese occur in Brazil, but as yet have not been worked.

Saltpetre is frequently found in caves, one near Diamantina having yielded 40 tons of crystals; but the total production has not been over 1000 tons.

Chrysoberyls and topaz are found in the diamond washings, and in former years a considerable amount of these stones was exported. In 1868 white or limpid topaz was worth $5.50 per lb., and about 250 lbs. were exported, but since the failure of the diamond washings only occasional small lots have been exported.

CHILE.

Since the conquest of the desert of Tarapacá, Chile has become the first among South American nations in importance and value of mineral production, the nitrate output alone having increased from 741 metric tons, worth $40,262, in 1878, to 1,025,617 tons, worth $36,925,414, in 1890. Following the development of the nitrate industry came that of iodine and manganese, both of which have likewise rapidly increased.

In the following tables the figures for the years 1844 to 1890 are official, being taken from a compilation made by the *Sociedad Nacional de Mineria* from the custom-house records; those for 1889 are from the *Memoria de Hacienda* for 1890; and those for 1890 are from a review of the *Comercio Esterior de Chile,* by Alberto Herrmann, in the *Boletin de la Sociedad Nacional de Mineria,* No. 46, 1892.

The figures for 1891 are unofficial, being taken from various sources, as shown by the foot-notes. The columns giving the total output of gold and silver are taken from the Reports of the Director of the United States Mint.

It is to be noted that the official part of the tables does not represent the total production, but the amount and value of the metals and ores exported. However, it is probable that, with the exception of coal, the amount produced for home consumption does not exceed five per cent of that exported.

The year 1878, which witnessed the first exportation of Chilean nitrate, was in many respects notable in the mining and metallurgical industries of the country, a constantly increasing export of calcium borate, gold, guano, iodine, nitrate, and silver, and a constantly decreasing export of copper bars, matte, and ores, and argentiferous lead dating from that time.

MINERAL EXPORTS OF CHILE SINCE 1844.

Year.	Coal.		Cobalt Ores.		Copper Bars.		Copper Matte.*		Copper Matte, Argentiferous.†	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1844..	5,156	$39,327	2.3	$87	4,026.1	$1,236,747	5,085.3	$437,352	....	....
1845..	1,369	10,312	....	....	4,382.7	1,313,687	4,268.1	330,531	....	....
1846..	230	2,401	....	....	6,006.5	1,778,525	4,743.3	345,504	....	....
1847..	4	84	4.8	416	6,481.1	1,899,253	3,965.3	298,667	....	....
1848..	1	10	68.4	4,654	6,920.4	2,081,347	3,908.9	275,804	....	....
1849..	632	4,523	352.4	23,058	8,220.9	2,445,768	2,730.9	204,160	....	....
1850..	431	7,490	266.8	10,709	9,116.1	2,653,979	5,024.5	333,534	....	....
1851..	229	2,540	8.4	360	6,022.2	1,749,780	3,031.7	216,539	....	....
1852..	6,623	74,437	......	....	9,729.7	2,736,951	6,675.1	473,490	....	....
1853..	5,788	43,188	....	....	5,823.1	1,854,659	5,400.7	465,677	....	....
1854..	24,341	163,623	....	....	7,911.5	2,772,364	6,633.9	662,269	....	....
1855..	17,079	91,982	200.0	8,219	8,177.2	2,929,066	11,860.3	1,729,793	....	....
1856..	30,986	195,670	....	....	6,418.9	3,000,173	16,839.5	3,314,579	....	....
1857..	36,212	213,910	67.8	2,059	6,281.5	3,008,610	23,135.9	4,672,514	....	....
1858..	34,200	185,944	233.5	19,155	8,724.8	3,922,003	15,579.2	2,759,785	....	....
1859..	68,839	408,856	130.3	9,885	9,345.7	4,063,340	14,963.5	2,927,646	299.8	$195,510
1860..	47,192	274,041	332.1	14,453	13,456.7	5,821,362	18,487.4	3,966,207	814.0	530,850
1861..	53,342	336,099	227.8	7,427	14,499.8	5,594,610	22,740.9	3,584,168	581.3	214,846
1862..	47,597	263,830	46.0	370	12,704.2	4,918,100	33,442.9	5,307,254	868.2	184,875
1863..	44,948	283,124	245.5	19,643	14,969.5	5,545,046	20,250.8	2,960,563	903.2	528,943
1864..	44,960	287,725	143.9	3,599	23,805.0	9,506,957	29,468.2	4,714,912	846.8	496,687
1865..	48,442	251,442	37.1	5,097	16,801.7	6,208,652	39,360.8	6,266,170	1,163.9	404,462
1866..	31,856	170,374	26.5	398	19,005.2	6,351,842	20,073.6	4,820,769	762.1	383,327
1867..	40,766	223,602	51.6	2,581	25,475.0	8,916,251	28,550.5	4,216,972	1,443.1	981,735
1868..	43,445	188,305	....	....	27,385.9	8,211,729	25,919.6	2,905,350	1,302.1	781,340
1869..	37,742	215,155	....	....	28,108.1	5,662,346	41,829.6	5,299,443	1,445.9	925,412

* 50% copper. † 50% copper; 0.53% silver.

MINERAL EXPORTS OF CHILE SINCE 1844.—*Continued.*

Year.	Coal.		Cobalt Ores.		Copper Bars.		Copper Matte.*		Copper Matte, Argentiferous.†	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1870..	40,538	228,318	15.3	1,909	24,261.3	8,067,178	36,138.8	4,250,898	2,305.2	346,185
1871..	66,267	350,653	85.7	21,431	19,824.3	5,947,283	33,634.6	4,612,900	4,807.5	1,640,068
1872..	63,565	527,623	83.3	9,452	27,097.8	8,129,325	27,071.4	2,362,297	6,466.7	3,060,803
1873..	27,695	276,441	250.4	23,116	27,456.7	8,310,377	22,110.9	3,316,811	3,145.4	831,181
1874..	42,468	411,209	685.4	56,290	33,372.5	8,143,661	23,205.9	3,543,761	4,061.8	860,473
1875..	37,831	244,713	183.0	9,243	35,594.3	10,950,504	17,396.9	3,018,149	3,127.9	702,331
1876..	46,280	326,526	92.5	15,322	41,766.2	16,079,969	14,632.6	2,519,741	4,862.5	1,130,790
1877..	102,250	487,709	171.2	20,930	35,128.2	11,767,955	10,763.4	1,270,788	3,517.4	747,645
1878..	104,478	649,183	167.9	16,366	40,894.6	13,026,285	11,750.8	1,435,267	2,888.0	478,756
1879..	72,308	578,464	92.3	7,649	39,176.6	14,456,061	10,296.6	1,369,759	4,145.7	749,797
1880..	59,273	404,872	76.8	11,517	32,542.2	13,912,631	9,382.6	1,431,314	3,062.4	747,519
1881..	92,746	631,121	105.7	21,148	32,837.3	13,606,798	10,208.1	1,808,526	2,609.1	720,899
1882..	111,232	741,027	75.4	13,538	36,726.1	14,778,333	12,263.8	2,066,649	3,209.8	688,638
1883..	148,632	975,000	111.7	6,704	34,822.6	13,682,290	5,755.5	807,392	4,197.3	780,338
1884..	140,426	1,151,916	67.7	5,419	35,890.0	11,231,006	9,946.9	1,223,033	4,973.0	990,805
1885..	111,922	736,066	216.8	13,185	36,071.4	9,424,174	3,476.6	382,424	3,174.5	634,891
1886..	129,855	779,130	122.2	7,332	34,915.0	8,186,426	2,527.5	278,033	2,423.3	561,059
1887..	153,255	919,530	215.5	12,928	26,733.1	6,993,137	3,988.5	478,615	1,999.4	499,851
1888..	128,236	1,314,259	25.0	3,745	31,336.0	13,878,439	2,283.3	456,668	1,905.6	762,251
1889..	146,208	1,315,872	......	......	20,145.7	5,689,329	4,566.9	456,695	2,727.6	818,277
1890..	194,676	1,674,394	......	......	24,287.8	8,543,469	1,420.0	220,619	2,499.1	879,977
Total	2,692,701	$18,689,020	5,289.2	$409,394	980,683.4	$330,987,777	696,792.0	$100,799,991	82,540.6	$24,260,521

* 50% copper. † 50% copper; 0.53% silver.

MINERAL EXPORTS OF CHILE SINCE 1844.

Year.	Copper Ores.		Copper, Silver Ores.		Gold.		Gold Ores.		Gold and Silver Ores.		Guano.	
	Tons.*	Value.	Tons.†	Value.	Kilos.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1844 .	9,459.1	$376,420	......	......	217.22	$116,367	......	......	......	......	937.7	$12,536
1845..	6,752.4	269,665	......	......	376.72	218,875	......	......	......	......	4,708.7	93,663
1846..	9,865.8	381,260	......	......	371.40	217,944	......	......	......	......	2,202.7	24,534
1847..	4,350.5	166,485	......	......	258.18	301,415	......	......	......	......	216.7	2,356
1848..	4,104.6	173,290	......	......	545.45	296,440	......	......	......	......	880.8	10,379
1849..	3,536.6	118,492	......	......	484.05	263,070	......	......	......	......	1,255.4	13,645
1850..	2,382.9	90,211	9.2	$351	64.34	35,343	......	......	......	......	3,479.2	37,708
1851..	2,775.6	106,195	......	......	551.54	299,753	......	......	......	......	3,744.6	55,392
1852..	10,429.8	366,322	1,399.4	49,107	......	......	......	......	......	......	5,066.7	82,609
1853..	20,912.2	685.507	1,480.6	63,743	10.81	6,006	......	......	......	......	1,792.4	24,174
1854..	20,471.9	881,983	88.9	5,963	4.74	2,640	......	......	......	......	1,625.4	26,502
1855..	25,765.5	1,355,489	465.0	97,156	1.44	781	......	......	......	......	722.8	15,714
1856..	28,978.7	1,841,936	490.9	313,470	9.20	5,072	......	......	......	......	1,118.5	18,237
1857..	30,417.3	1,953,600	90.1	63,915	2.87	1,600	......	......	......	......	432.1	9,394
1858..	40,912.2	2,713,931	474.9	115,420	58.91	35,229	......	......	......	......	1,253.4	27,248
1859.	31,963.5	3,413,268	124.3	81,075	......	......	......	......	......	......	366.3	7,964
1860..	55,032.7	4,387,781	58.7	42,430	19.97	12,256	......	......	......	......	......	......
1861..	37,247.7	1,923,600	41.9	6,377	7.96	4,490	......	......	......	......	......	......
1862..	36,359.2	2,196,369	178.2	27,118	53.19	29,600	......	......	......	......	75.8	1,237
1863..	30,783.5	1,853,723	73.3	10,842	73.78	40,565	......	......	......	......	2,967.0	59,333
1864..	18,468.6	1,268,588	159.9	22,037	35.75	18,802	......	......	......	......	......	......
1865..	20,637.3	1,268,276	131.4	19,717	33.39	18,029	......	......	......	......	......	......
1866..	18,265.6	963,648	102.4	6,292	4.30	2,325	......	......	......	......	......	......
1867..	13,476.5	739,186	......	......	7.17	3,858	......	......	......	......	......	......
1868..	5,588.4	286,660	51.6	3,375	......	......	......	......	......	......	217.9	4,359
1869..	10,282.9	596,1[illegible]2	......	......	......	......	......	......	......	......	......	......
1870..	3,462.1	208,[illegible]6[illegible]	177.8	17,087	0.30	445	......	......	17.48	$3,097	......	......
1871..	1,950.5	115,083	226.9	50,446	......	......	......	......	......	......	......	......
1872..	24,461.8	1,698,727	128.2	8,689	146.11	81,823	45.2	$1,358	9.77	880	......	......
1873..	9,484.6	431,221	1,194.9	51,789	......	......	2.9	89	.52	46	......	......
1874..	5,865.5	315,603	201.6	17,059	......	......	......	......	134.12	12,034	......	......
1875..	8,696.3	410,552	488.8	46,544	8.89	4,436	......	......	13.01	566	......	......
1876..	3,931.0	284,609	54.6	6,687	52.17	46,211	......	......	9.86	1,973	......	......
1877..	6,813.3	346,589	56.1	8,740	20.13	20,131	......	......	9.08	7,111	......	......
1878..	1,411.1	64,588	268.9	23,265	21.00	21,000	......	......	......	......	......	......
1879..	81.1	7,573	53.1	8,560	22.86	22,856	......	......	......	......	9,254.0	416,431
1880..	3,933.0	137,215	184.7	28,386	21.39	21,393	......	......	......	......	23,555.2	824,225
1881..	3,517.8	223,586	30.8	2,210	35.42	35,416	......	......	4.45	834	51,563.2	1,792,411
1882..	3,031.1	190,922	161.4	18,067	25.93	22,796	......	......	......	......	33,814.5	1,014,437
1883..	1,222.6	77,335	92.2	8,860	69.83	52,220	......	......	.05	100	175,430.3	5,262,910
1884..	5,576.5	203,500	387.2	25,640	117.59	96,655	......	......	......	......	37,762.5	1,132,874
1885..	1,577.1	80,930	551.4	63,352	100.97	100,970	......	......	177.05	31,748	11,651.5	349,545
1886..	267.9	13.398	132.9	13,289	241.87	193,498	90.3	17,707	177.60	26,641	70,988.0	2,129,642
1887..	621.6	31,079	261.5	26,148	463.08	370,463	3,436.6	1,148,899	9.35	1,869	1,282.0	38,462
1888..	1,647.3	131,782	116.5	16,473	935.75	748,596	3.795.5	1,213.834	1.68	385	51,167.9	1,535,035
1889..	4,463.0	178,522	462.7	42,768	415.38	332,301	1,465.5	515,820	2,365.90	591,483	83,009.7	2,429,991
1890..	1,175.9	68,794			665.17	531,945	1,818.2	418,200	1,230.90	275,555	41,323.4	1,237,003
Total	582,412.1	$35,597,679	10,653.9	$1,412.447	6,556.22	$4,637,815	10.654.2	$3,315,907	4,150.82	$954,322	623.866.3	$18,689,950

* 20% copper. † 15% copper; 0.63% silver.

MINERAL EXPORTS OF CHILE SINCE 1844.

Year.	Silver Bars.		Silver, Old Plate.		Silver, Lead.		Silver Lead Ores.		Silver Ores.		Silver Sulphide Ores.	
	Kilos.	Value.	Kilos.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1844..	27,595.49	$1,230,458	81.17	$2,875	......	....	......	....	35.9	$4,056	......	....
1845..	35,949.15	1,655,698	106.07	4,610	......	....	......	....	130.3	12,824	......	....
1846..	40,522.78	1,773,949	12.42	540	......	....	......	....	51.0	2,803	......	....
1847..	40,562.58	1,798,083	305.80	13,240	......	....	......	....	54.6	9,628	......	....
1848..	49,469.17	2,239,644	96.64	3,780	......	....	......	....	150.9	22,838	......	....
1849..	71,185.69	3,215,572	102.85	4,023	......	....	......	....	46.3	4,418	......	....
1850..	92,381.50	3,914,148	109.75	3,816	......	....	......	....	332.5	41,385	......	....
1851..	80,160.00	3,277,319	23.01	800	......	....	......	....	1,908.4	270,018	......	....
1852..	85,665.44	3,511,553	36.12	1,206	......	....	......	....	4,807.7	487,843	......	....
1853..	56,850.67	1,738,054	......	....	......	....	......	....	5,048.7	1,454,555	......	....
1854..	69,391.85	2,714,193	9.02	640	......	....	......	....	7,250.4	1,428,462	......	....
1855..	62,352.51	2,648,746	5.06	154	......	....	......	....	11,766.7	1,603,889	......	....
1856..	56,746.43	2,589,563	......	....	......	....	......	....	6,460.3	1,076,730	......	....
1857..	34,730.32	1,584,254	5.75	250	......	....	......	....	4,521.7	1,279,151	......	....
1858..	27,383.80	1,248,666	4.14	180	......	....	......	....	3,895.4	784,397	......	....
1859..	15,954.00	718,829	277.27	6,025	......	....	......	....	4,343.4	379,267	......	....
1860..	33,624.02	1,534,066	156 00	4,746	......	....	......	....	5,347.4	906,210	......	....
1861.	28,354.35	1,308,680	362.17	11,018	......	....	......	....	4,735.7	830,188	......	....
1862.	47,791.30	2,180,861	210.31	6,312	......	....	......	....	5,553.4	1,026,228	......	....
1863..	49,357.00	2,241,476	294.00	10,958	......	....	......	....	4,365.9	1,021,318	......	....
1864..	35,539 00	1,638,272	504.00	16,632	......	....	12.3	$368	3,786.5	810,243	......	....
1865..	22,009.00	1,001,666	240.00	8,880	......	....	......	....	2,621.6	626,629	......	....
1866..	37,916.00	1,694,350	152.00	5,030	177.2	$35,224	......	....	1,864.2	143,985	......	....
1867..	64,592.00	2,906,640	283.00	9,905	310.1	40,500	210.5	14,737	2,314 9	130,686	......	....
1868..	69,545.55	3,129,551	51.31	1,694	575.4	87,973	340.3	31,532	1,050.1	68.751	......	....
1869..	82,523.80	3,300,943	50.00	1,500	816.8	163,236	238.3	23,830	872.5	82,051	......	....
1870	45,600.51	1,828,409	48.90	1,604	615.6	123,113	228.8	21,481	1,889.6	293,571	......	....
1871..	53,534.09	2,409,033	27.00	945	440.4	88,091	506.2	61,887	1,578.5	376,492	......	....
1872..	36,995.53	1,664,599	15.50	543	197.8	39,435	182.7	38,017	823.0	167,132	......	....
1873.	64,827.23	2,917,225	......	....	......	....	760.4	58,524	769.9	127,693	......	....
1874..	74,819.85	2,992,818	......	....	......	....	......	....	1,001.9	163,957	......	....
1875..	73,463.14	2,938,510	......	....	57.3	31,907	277.7	27,774	159.8	43,918	......	....
1876..	34,799.74	1,394,565	60.65	2,053	117.1	77,090	159.5	12,939	66.2	22,076	......	....
1877..	43,101.16	1,724,046	26.00	910	282.7	128,291	1,241.9	86,973	326.1	58,999	......	....
1878..	41,148.40	1,645,935	7.09	142	362.8	53,776	582.0	35,220	111.2	21,930	......	....
1879..	60,213.14	2,408,526	34.50	872	1,061.8	160,983	......	....	40.8	9,094	......	....
1880..	84,284.11	3,372,740	70.18	2,445	585.0	75,884	114.2	3,455	78.3	14,640	6.6	$30.305
1881..	37,560.13	1,593,395	18.12	362	250.2	69,724	275.4	19,100	5.7	3,299	14 1	129,173
1882..	96,631.70	3,909,852	35.42	1,399	127.8	20,613	21.7	2,740	4.5	13,533	5.4	45,303
1883..	76,681.42	3,074,842	2,636.24	94,903	91.5	43,919	32.8	6,500	363.8	307,466	.5	5,433
1884..	66,465.60	2,989,355	94.34	3,000	80.8	6,609	58.1	16,654	5.2	1,980	......	....
1885..	155,616.59	6,768,902	297.80	9,248	81.3	5,687	......	....	229.2	27,158	.7	6,780
1886..	154,545.56	6,566,715	129.00	3,870	39.6	2,773	5.4	651	76.6	9,189	......	....
1887..	193,736.96	8,291,920	55.90	1,677	19.0	1,766	......	....	215.4	22,955	96.6	120,721
1888..	182,672.85	7,723,957	330.23	9,907	18.8	1,316	......	....	248.2	62,039	140.1	175,186
1889 .	123,695.60	4,906,791	......	....	} 296.7	61,564	782.0	117,300	{ 669.6	179,924	} 39.0	48,778
1890..	101,925.20	4,335,219	......	....					1,676.3	926,374		
Total	3,120,381.95	$132,252,588	7,370.76	$252,694	6,605.87	$1,319,474	5,839.3	$579,582	93,656.8	$17,371,973	303.0	$561,679

MINERAL EXPORTS OF CHILE SINCE 1874.

Year.	Borax.		Calcium Borate.		Iodine.		Manganese Ores.		Nitrate.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874....	180.0	$27,010	273.4	$29,529	....	....	....	....	....	....
1875....	248.1	54,375	11.9	719	....	....	....	....	....	....
1876....	....	....	46.8	3,347	....	....	....	....	....	....
1877....	....	....	....	....	....	....	....	....	....	....
1878....	....	....	0.6	120	....	....	....	....	741.5	$40,262
1879....	....	....	679.9	135,984	77.35	$1,160,205	....	....	59,344.1	4,747,529
1880. ..	....	....	644.9	128,982	83.86	1,236,981	....	....	226,090.3	15,425,558
1881....	....	....	3,140.5	628,097	200.06	2,953,628	....	....	358,105.9	22,891,786
1882....	....	....	4,311.9	862,379	263.98	3,963,240	....	....	489,346.5	28,698,364
1883....	1,497.6	299,527	1,559.7	124,780	220.92	2,987,491	....	....	584,798.4	32,043,572
1884....	842 4	168,480	1,367.7	70,386	218.19	2,181,947	4,324.0	$21,620	559,646.3	25,163,038
1885....	94.5	14,174	1,868.6	93,431	256.80	2,567,960	8,160.2	57,247	429,662.5	20,654,122
1886 ...	1,519.7	227,960	200.4	10,020	175.68	1,756,860	24,375.7	243,757	452,788.3	19,230,047
1887....	3,053.3	457,980	1,453.2	72,680	77.20	771,960	47,504.4	475,044	712,767.8	28,690,970
1888....	538.3	80,742	1,131.6	56,578	91.37	913,750	17,947.1	179,471	784,249.8	33,866,196
1889....	....	....	3,670.2	183,509	201.39	2,013,950	26,452.9	264,529	921,388.0	36,387,210
1890 ...	....	....	3,536.1	176,809	419.74	4,197,420	50,997.5	509,975	1,025,617.1	36,925,414
1891....	....	....	....	....	424.02	4,240,190	....	....	891,727.1	32,418,491
1892....	....	....	....	....	....	....	....	....	....	....
Total ..	7,973.9	$1,330,448	23,897.4	$2,577,350	2,710.56	$30,945,522	179,761.8	$1,751,673	7,496,273.7	$337,182,559

Nitrate.—The nitrate industry in Chile supplies more than half the exports, and pays to the National Treasury over $20,000,000 per annum in export duties. For its development millions of English capital have been invested in the construction of water-tanks, dwellings, and railways, and in the payment of wages. At present the greater part of the business is in the hands of 19 companies, whose aggregate capital is $27,575,000.

The discovery of sodium nitrate in the *caliche* of Tarapacá dates from 1821, at which time the territory belonged to Peru. Exports began in 1830, the crude nitrate being worth about 11 cents per kilogram. From 1830 to 1878, the period of Peruvian occupancy, there was exported a total of 3,891,664 metric tons. Since 1878 the exports have been 7,496,273 tons, worth $337,182,559, from which the Chilean Government has collected $158,696,664 in duties and charges (*recargos*).

The nitrate is exported to the different countries as follows: To the United Kingdom and Continent, for orders, 65%; to Germany, 15%; to France, 6%; to England, 3%; to Holland, 1.5%; to the Mediterranean, 1.3%; and to the United States, 10%.

The accompanying chart shows the exportation since 1830 and the fluctuation in price since 1877:

EXPORTS OF NITRATES FROM PERU AND CHILE.

Year.	Metric Tons.	Year.	Metric Tons.	No. of Workmen.	London Price per Ton.	
					Lowest.	Highest.
1830–1834	16,735	1877	231,665			
1835–1839	35,247	1878	325,139	....	....	....
1840–1844	74,180	1879	146,342	2,848	....	....
1845–1849	95,397	1880	225,417	4,906	$65.36	$74.40
1850–1854	150,948	1881	358,287	7,124	57.60	69.20
1855–1859	261,049	1882	495,416	7,077	49.20	60.00
1860–1864	323,111	1883	593,518	6,505	43.80	49.68
1865–1869	490,464	1884	562,592	4,571	44.20	55.40
1869	116,065	1885	438,796	4,534	42 84	55 40
1870	182,546	1886	453,932	7,201	42.40	56.60
1871	166,944	1887	722,787	9,180	44.00	55.28
1872	204.676	1888	784,249	11,422	40.20	44.40
1873	290,000	1889	921,388	....	....	....
1874	258.472	1890	1,025,617	....	47.40	47.30
1875	332,917	1891	891,727	....	....	....
1876	338,750					

Guano.—The guano deposits of Chile, as well as the nitrate deposits, formerly belonged to Peru, and were worked on a far more extensive scale than at present.

Before 1875 Europe annually consumed about 350,000 tons of Peruvian guano, which was worth, approximately, $60 per ton. When Chile took possession of the islands in 1878, it was estimated that not over 700,000 tons of merchantable guano remained for shipment. Since then 623,000 tons have been exported, and it is believed that the deposits are nearly exhausted, although a second bed, capped by sand, was discovered some years ago at Lobos. The guano exported during 1888 contained nitrogen and phosphoric acid as follows:

	Nitrogen.	Phosphoric Acid.
Pabellon de Pica	6.4–6.75%	16.10–16.70%
Huanillos	2.7–4.14%	24 –28%
Lobos	2.5–3.5%	21 –30%

Notwithstanding the rapid exhaustion of the guano deposits, the price has steadily depreciated, owing to the large amount of ammonia recovered from gas

works, the discoveries of large quantities of mineral phosphates in Florida, and the utilization of Thomas slag.

Gold.—Gold-mining in Chile since 1844 can be divided into three periods, viz., from 1844 to 1851, 1853 to 1872, and 1875 to 1892. The first period was one of placer-washing, the maximum annual output being 551 kilograms, in 1851. During the second period but little gold was produced, the maximum being 146 kilograms, in 1872, while in 1852, 1859, 1868, 1869, 1871, 1873, and 1874 none at all was produced for export. In 1875 about eight kilograms were exported, and since then the production and exports have been constantly on the increase. The causes of this increase are to be found in the discovery of the placers of Guanaco, in the adoption of chlorination, and in the recovery of the gold contained in much of the copper matte of Chile.

The principal gold-mining districts are Talca, de Alhue and Leona in the department of Rancagua, Petorca in Aconcagua, Tamayo and Andacollo in Coquimbo, and Inca, Jesus-Maria, and Cachiyuyo in Atacama.

Mr. Herrmann, in his review of the commerce of Chile, estimates the total production of the country from 1844 to 1890 to be as follows:

Exports:	Gold ores	10,654.429 kilos =	6,656.40 kilos gold =	$3,312,907
	Gold and silver ores	4,160,866 " =	1,907.56 " " =	954,272
	Gold bullion		6,556.1 " " =	4,637,815
	In silver bullion and silver lead		2,054.34 " " =	1,500,000
	Bought and coined by Chilean Mint		6,456 86 " " =	4,700,000
			23,632.17 kilos gold =	$15,104,994

Since 1772 the Chilean Mint has bought and coined gold to the value of $66,011,972.24, the piece coined being the condor, containing 13.7277 grams of fine gold.

Silver.—Silver-mining ranks next in importance to that of copper and nitrate among the mining industries of the republic. Except for a few years, the production has shown a constant increase in amount and value. The most productive mines have been those of Chañarcillo and Tres Puntas, in Copiapo, which since 1844 have produced bullion of the value of $120,000,000. At present the most important mines are those of Huantajaya and Challacollo, in Tarapacá, and Caracoles and Arturo Prat, in Atacama. Before 1855 only free-milling silver ores were worked in the country, the others, if of high grade, being exported. Since that year the exportation, which was then at its maximum, has gradually declined owing to the introduction and extended use of improved processes of treatment.

In 1859 a method of concentrating silver in copper matte was adopted, and 299 tons of matte were exported in that year. The exports of this argentiferous copper matte steadily increased until 1872, when they amounted to 6466.7 tons, valued at $3,060,803; since then they have shown a decline. At present this method of treatment is receiving renewed attention and is used at the reduction works of Cousiño and Vattier at Maitenes. The matte made by the latter contains 75% copper and from ½% to 3% silver.

In 1864 the Tina process was introduced by M. Herzog, and the export of silver ores again showed a rapid decrease, which was accompanied by as rapid an increase in the production of silver bullion. This process is now used in the reduction works at Copiapo, Totoralillo, and Puguios, and at the new works of the Huanchaca Mining Company at Antofagasta.

The total production of silver since 1844 is estimated by Herrmann as follows:

Exports: Argentiferous copper matte / " " ore	93,194,216 kilos	= 587,113.56	kilos silver	= $18,000,000
Silver bullion		3,120,481.95	" "	132,252,588
Silver plate		7,379.76	" "	252,694
Silver sulphides		18,722.60	" "	561,679
Silver ores	93,656,774 kilos	= 579,099.10	" "	17,372,973
Silver ores for mineral collections		1,629.61	" "	48,887
Silver bullion bought and coined by Chilean Mint		984,190.40	" "	43,743,756
		5,298,616.98	kilos silver	= $212,232,577

According to the same authority, the Chilean Mint has coined silver of the value of $53,423,304.23 since 1772.

Copper.—Viewed from the point of value of total output, copper mining and smelting is the most important of the mineral industries of the republic, the value of the amount produced being 40% greater than that of nitrate and more than double that of silver; but since 1878 it has been a waning industry, and as yet there are no signs of recovery. The causes for the decline in production are numerous, the principal ones being the exhaustion of some of the most important mines, such as those of Tamaya, Higuera, and Carrizal, and the partial abandonment of others, such as Poposo and Cerro Blanco.

In many of these mines the ore became much poorer in depth as well as less in quantity, which, taken in connection with the increased cost of mining the ore, has made the working unprofitable. According to Herrmann, two very important reasons for the decline are found in the lack of improved processes of treatment and in the neglect of the gold and silver contained in the ore. All of these reasons have been and are accentuated by the steady decline in the price of Chile bars. In 1855 Chile produced one half the copper consumed in the world, in 1880 about one fifth, and to-day less than one tenth. Before 1842 the metallurgical practice in this country was very simple, high-grade oxides and carbonates being smelted in charcoal furnaces. In this year Lambert introduced reverberatory furnaces, and such was his success that in a short time their use was general throughout the country. From this time to 1884, when M. Charles Vattier introduced the David-Manhes process, the metallurgy of copper remained stationary. The principal copper-producing districts are Coquimbo, Atacama, Lota and Coronel, Valparaiso and Tocopilla, in the order named; the principal reduction and smelting works are those of Cousiño and Vattier at Maitenes, of Lambert at Coquimbo, and those of Chañaral, Guaycan, and Tongoy.

According to Herrmann, the exports of copper from 1844 to 1890 were as follows:

			Metric Tons.	Value.
Copper bars			980,683.6	$323,409,096
Copper matte	694,444.4 tons	= 50% Cu.	348,222.2	100,461,334
Copper ore	592,412.6 "	20% Cu.	118,482.5	35,597,689
Copper matte argentiferous	82,540.6 "	50% Cu.	41,270.3	7,672,968
Copper ore "	10,653.6 "	15% Cu.	1,598.1	
			1,490,256.7	$467,141,087

The copper exports to England during the 11 months ending Nov. 30, 1892, were as follows: Ore, 1474 tons, worth £16,207, against 3643 tons, worth £52,212, the same 11 months of 1891; matte, 4355 tons, worth £106,670, against 1069 tons, worth £36,474, in 1891; bar copper, 13,261 tons, worth £602,621, against 10,807 tons, worth £322,632, in the same 11 months of 1891.

Coal.—Coal-mining has shown, with but few exceptions, a steady increase in output, and a considerable quantity is now exported for use by the Pacific-coast steamers, and at various points in Peru. The Carboniferous area is divided into two groups, widely different in their geological aspects. The lignite beds of the northern and central parts of Chile are very irregular, and occur interstratified with the secondary rocks of the Andes, the whole being subordinate to porphyry. The mines in the Cordillera de Rancagua and those near Copiapo are of this class.

In the mines of the south the lignite is of Tertiary formation, and the beds are regular and easily worked. The most important of these mines, which supply nearly all the coal used in the country, are those of Lota, Buen Retiro, Carampangue, and Lebu. The mines of Lota and Buen Retiro belong to the Cousiño family. The former is developed by 5 vertical shafts from 100 to 170 meters deep and an incline shaft 900 meters long. Three beds are worked, the general strike being north and south, with a dip of 12°. The chamber and pillar method of working is employed: the pillars are large, being 12 m. × 12 m. Power is supplied by 12 engines having a total of 270 horse-power. A railroad 3 kilometers long takes the coal to the wharf, at which 1200 tons can be loaded daily. The number of men employed varies from 1000 to 1500, and at least 200,000 tons are mined annually. These mines have been worked since 1853.

The mines of Buen Retiro are similar in many respects to those of Lota. At the end of 1889 the galleries extended 900 meters under the sea, with a roof 150 meters thick. At the same date 200 miners were employed, producing 30,000 tons per annum.

The principal mine in the Carampangue district is that of Maquegua, which is worked by the Arauco Company, Limited; 800 men are employed, producing 84,000 tons annually. According to Don Carlos Vattier, the cost of production is about $3 per ton.

The mines of Lebu belong to and are worked by the Errazuriz family. There are 4 beds of coal, varying from 0.75 meter to 1.7 meters in thickness, which are worked by 4 shafts from 170 to 360 meters deep. The number of miners employed varies from 600 to 900 according to the time of the year. Eighty thousand tons are produced annually.

ANALYSES OF CHILEAN LIGNITE.

	Lota.	Buen Retiro.	Carampangue.
Moisture	5.00	4.8	....
Volatile matter	40.20	40.8	48.2
Fixed carbon	53.20	48.2	50.3
Ash	1.60	6.2	1.5
	100.00	100.0	100.0

Iron.—Although iron ores in large quantities and of fair quality are of frequent occurrence in Chile, but little ore is mined except that used in copper and silver smelting.

In the Province of Coquimbo the following mines produced ore during 1888 or 1889: Peñon, 7000 tons, and a total of 30,000 since 1884; San Cristobal, now abandoned, 7000 tons; Serena, and Higuera.*

* Don Carlos Vattier, *El Porvenir de la Metalurgia del Fierro en Chile.*

In the Department of Illapel iron occurs, associated with manganese ore, at Curico, Huintel, and Portezuelo. These ores contain from 54% to 62% metallic iron, and sometimes as much as 2.9% copper. In 1888 Brunel, Lewis & Co. of Antofagasta used 3697 tons in their silver-reduction works, which amount was increased to 4306 tons during the first 10 months of 1889.

Besides the minerals and ores mentioned in the following tables, there have been exported the following: Clay, 1863 to 1888, about 823 tons, value $25,039; lime, 1884 to 1888, about 1597 tons, value $27,650; rock crystal, 1861 to 1876, about 23 tons, value $4283; lapis lazuli, 1852 to 1857, about 57 tons, value $13,638.

Herrmann estimates the value of the total mineral production since 1844 to 1890, inclusive, at $671,203,567.

. . . .

Although Chile takes high rank as a mineral-producing country, the metallurgical and manufacturing industries have not attained a corresponding development, as may be easily seen from the list of articles imported. Taking the average of the years 1889 and 1890, there was imported machinery to the value of $6,227,787, the principal item being material for railway construction; iron and steel of the value of $5,088,043, the principal items being wrought and cast iron pipes, rails, galvanized iron, bars and ingots, nails and wire; copper in sheets, nails, etc., and sulphate and brass of the value of $162,753; lead, pigs and sheets, and paint of the value of $257,712; iron and steel tools, $243,239; Roman cement, $105,778; salt, $89,279; dynamite, $47,264; zinc, $71,935; mercury, $41,760; sulphur, $101,726; coal and coke, $3,083,791. The total value of these imports in 1889 and 1890 was $15,521,067.

British Guiana.

In 1884 gold was discovered in the sands of the Cuyuni River, and in the following year in the Mazuruni, both tributaries of the Essequibo River, for many years considered the western boundary of British Guiana. The region was quickly overrun by English and Portuguese, and the Colonial Government soon after took possession of the country and established rules and regulations for acquiring land and working the mines. The claims of England to this territory date back to a map published by Sir Robert Schomburgk in 1840, but actual possession was not taken until the discovery of gold. Venezuela has made numerous protests to what it calls usurpation of its territory, and has sought by treaty and otherwise to have the question of boundaries settled, but so far without avail.

Since the first discovery of gold the country extending west to the head-waters of the Yuruari River has been thoroughly explored, and many valuable auriferous deposits have been discovered. The results obtained in the west led to prospecting in the north, on the Barima, Amacuro, and Pomeroon rivers, and many valuable placers have been discovered. The output of gold has steadily increased, and is still increasing at a rapid rate.

The production since 1885 has been as follows, in kilos of fine gold:

Year.	Kilos.	Value.	Year.	Kilos.	Value.
1885	23	$15,596	1889	788	$524.325
1886	168	112.042	1890	1,692	1,124,759
1887	320	213,252	1891	2,710	1,801,389
1888	401	266,718	1892	3,513	2,334,743*

* Demerara *Herald*.

Dutch Guiana.

Gold was discovered in Dutch Guiana, or Surinam, in 1862, but the discovery excited no particular attention until 1875, when rich washings were found in the shallow creeks tributary to the Maroni River.

In the following year 500,000 acres of land were applied for and conceded, and at present the land held under mining title amounts to over 2,000,000 acres. Shallow places in creeks, dry rivers, and on the slopes of hills have alone been worked. The method of mining is either ground-sluicing or sluicing in long toms, few of the deposits being so situated as to permit hydraulic mining.

The yield since 1876 has been, in fine gold, as follows: *

	Kilos.	Value.		Kilos.	Value.		Kilos.	Value.
1876........	30	$20,060	1882.......	474	$315,460	1888.......	853	$567,139
1877........	177	117,939	1883.......	546	363,385	1889.......	680	452,345
1878........	246	163,638	1884.......	789	524,891	1890.......	668	444,200
1879........	411	273,325	1885.......	805	535,373	1891.......	†668	†444,200
1880........	555	369,306	1886.......	624	415,172	1892.......	944	627,025
1881	514	341,473	1887... ...	834	554,542			

† Estimated.

French Guiana.

Gold was discovered in 1853 in certain creeks flowing into the Approuague River. Later it was discovered in the basins of the Maroni, Mana, Sinnamary, and Oraput rivers. Exact statistics of the production of gold are not obtainable; but according to Mr. Fernand Viala, who has made an extensive examination of the deposits of this country, the production of the placers gradually increased until 1875, when the amount reported to the Cayenne custom-house was 1800 kilos. From 1875 the output very slowly decreased,—with the exception of 1879, when it reached 2000 kilos,—until in 1885 it was about 1400 kilos. In 1883 the Compagnie Générale de Mana commenced vein-mining near its placer, the Elysée; and within a few years various mines were being operated by the Saint-Elie, Dieu-Merci, Enfin, Mines d'Or, and Gisements Aurifères companies, and since 1885 the production has been quite constant at 1400 kilos. During 1892 the companies working both placers and veins showed renewed activity, and it is estimated, from various reports contained in the *Circulaire Chaumier*, that the production reached 2000 kilos.

From the data available it is estimated that the total production since 1853 has been from 45,000 to 50,000 kilos, valued at from $29,907,000 to $33,230,000.

Phosphate.—On the island of Grand Connetable, 27 miles from Cayenne, there is a large deposit of phosphate of alumina and iron, which is now being worked by the International Phosphate Company of New York.

This deposit was opened by the writer in 1887, and 2800 tons were shipped that year. Since then the shipments have averaged about 3500 tons, making a total production to date of 20,300 tons.

* From 1876 to 1889 the figures are official, being taken from the *Jaarcijfers en Vorige Jaaren*, No. 9. The figures for 1890 and 1891 are from the Director of the United States Mint. The production in 1892 is estimated by Mr. J. Fenelly, acting United States consul at Surinam. The gold passing through the custom-house up to Dec. 5 amounted to 945.04 kilos, worth 60c. per gram.

Colombia.

Colombia ranks third among the gold-producing countries of the world, without ever having had a famous mine or any so-called bonanza.*

Since the discovery of gold in 1537 its production has been remarkably constant, if the published statistics are correct, it having averaged 2000 kilos per annum from 1537 to 1600, 3500 kilos from 1600 to 1700, 4600 kilos from 1700 to 1800, and 3600 kilos from 1800 to 1890. The greatest amount produced in any one year was about 5600 kilos; the present production is about 4800 kilos.

Humboldt, in his *Essai Politique sur la Nouvelle Espagne,* estimated the production from 1537 to 1803 at $275,000,000, equal to 413,785 kilograms of refined gold; which is concurred in by M. Michel Chevalier, who gives the production from 1537 to 1848 at 556,748 kilos, valued at $370,014,720.

Danson estimates the production from 1804 to 1848 at $204,000,000.

Dr. Vicente Restrepo of Bogotá, the latest investigator of the gold and silver production of Colombia, does not agree with any of the preceding authorities, and estimates the production of the precious metals from 1537 to 1882 to have been as follows: From 1537 to 1600, $50,000,000; from 1600 to 1700, $170,000,000; from 1700 to 1800, $194,000,000; from 1800 to 1882, $216,000,000—a total of $630,000,000. This amount was made up of 876,774 kilos of gold, worth $582,684,062, and silver worth $47,315,938.

Dr. Restrepo divides the yield among the different States as follows: Antioquia, gold, $252,000,000; Cauca, including El Choco, $242,000,000; Panama, $74,000,000; Tolima, $40,000,000; and the other States, $22,000,000. Of the total amount $500,000,000 was placer gold.

Up to 1880 but few exact figures of the production of silver are obtainable. Soetbeer estimated the value of the silver produced from 1537 to 1876 at 6% to 10% of that of the gold, or from $49,227,402 to $82,045,670. Restrepo estimates the production from 1537 to 1882 at $47,315,938.

The production from 1880 to 1892, as given by the Director of the United States Mint, is as follows:

Year.	Kilos.	Value.
1880	24,057	$1,000,000
1881	24,057	1,000,000
1882	18,287	760,000
1883	18,287	760.000
1884	18,287	760,000
1885	9,625	400,000
1886	9,625	400,000
1887	24,061	$1,000,000
1888	24,061	1.000,000
1889	14,725	612,000
1890	19,971	830,000
1891	31,232	1,298,000
1892	......	1,806,000*

* Reported for this volume by Dr. Pereira Gamba.

The placers of Antioquia have been worked since about the middle of the sixteenth century, and still furnish a large part of the gold produced. The most important of the early placers were those of Zaragoza, Cruce, Anori, and Yarumal, and, later on, those of the Porce, Nechi, and Cauca rivers, which are still worked. The method of mining practiced is ground sluicing, and although the Antioquenios are extremely expert at it, their work is crude and wasteful compared with modern hydraulic practice.

The most important of the placers of Cauca, those of El Choco, were discov-

* According to Soetbeer, Colombia has produced a larger amount of gold than Brazil.

ered about 1650, since which time they have yielded about $130,000,000, the greater part of which has been taken from the bars of the San Juan, Atrato, Tamaná, and Sipi rivers. This district contains a peculiar class of placers called *caliche* deposits, which are of glacial origin.

The placers of Colombia are, as a rule, unsuitable for hydraulic mining, owing to the lowness of the banks and the lack of fall for the disposal of tailings. Among the earliest of the companies to engage in hydraulic mining was an American company, which commenced operations on the Telembi River, in the Barbacoas district, about 1880; it is said to have failed for want of capital. The Choco Hydraulic Mining Company spent some $50,000 for ditches, etc., on the Andagueda River; but there was no outlet for tailings, and because of this and the rising of the bed-rock, which lessened the head of water, the company was forced to suspend operations after a four-months' run, during which, however, it cleaned up about $12,000 worth of gold. Among the more successful of the hydraulic-mining companies is the Colombian Hydraulic Company, Limited, which during 1890 produced 6980 oz. of gold, and in 1891 some 2970 oz.

The first vein mines worked in Colombia were those of Buritica, in Antioquia, which were opened about 1560, and the ore was hand-crushed. About the beginning of the seventeenth century a number of veins at Marmato, in Cauca, were opened, the ore being picked out, crushed by hand, and washed in troughs of water. In 1641 Captain Arboleda introduced an engine for the working of these mines, but we have no description of it.

In the following century the silver mines of Supia and Echandia were discovered and worked, the ore being ground between two stones. The following description of this process of crushing with stones is taken from a letter written by Boussingault to Humboldt in 1826. The ore operated upon was the auriferous pyrites of Marmato.

"Around a circular pit, 10 ft. in diameter and 6 ft. deep, are 10 women, each with a block of porphyry 2 ft. high, and inclining to the well in front of her. The coarsely crushed pyrites is placed on the stone with a little water, and is ground by rubbing with another round stone, just as corn is ground. The fine pyrites falls into the pit. When the pit is full, water is allowed to run over the mass, which is frequently stirred for a period of 10 days, after which the material is removed and washed by hand in bateas."

In Tolima the first discovery of any importance was that of the silver mines of Mariquita in 1585, from which time they were worked, with few interruptions, up to 1727, when they were abandoned. It is said that at the time of their greatest prosperity, 1585 to 1620, they yielded 40 marks, or 320 oz., per ton.

In 1785 the mines of Santa Ana, El Cristo, and La Manta were reopened and worked for eleven years by D'Eluyar, who introduced the Freiberg process, during which the expenses reached $232,641, against a gross product of $27,247.

In 1824 the Santa Ana and La Manta mines were leased to Herring, Graham & Powles, of London, who immediately commenced work with a large force. This company put up smelting-works at a great cost, but the process did not succeed, and the firm returned to the use of the Freiberg amalgamation process. Up to 1836 the company had spent $1,109,488 and extracted silver worth but $138,740. The lease was abandoned in 1874.

According to Phillips, the production of this mine from 1852 to 1864 was as follows:

Year.	Ounces.	Year.	Ounces.	Year.	Ounces.
1852......	57,169	1857.......	158,036	1862.	93,436
1853.......	31,403	1858.... ..	160,036	1863.......	112,474
1854.......	55,009	1859......	140,509	1864.......	78,281
1855.......	84,415	1860.......	84,771		
1856......	129,389	1861......	81,044		

Restrepo estimates the gross yield from 1830 to 1874 at $4,500,000.

To return to Antioquia: In 1800 there were in operation only a few vein mines at Titiribi, Santa Rosa, and Dolores, and the placers of the Cauca, Nechi, and Porce rivers. In 1825 a rich vein at Anori was discovered, and here an Englishman named James erected the first mill for crushing quartz. These mills were quickly imitated all over the State, and with good success, more especially at the Bolivia, Zancudo, and Frontino mines. The next improvement was the introduction of a process for amalgamating the *jaguas*, or pyrites. In 1851 Mr. Tyrell Moore established the smelting-works of Titiribi to treat the auriferous silver ores of the Zancudo mine, but the process was a failure. A few years later Herr Paschke erected a second smelting-works for this mine, which is still worked.

At present the company has some 200 stamps worked by water-power, capable of crushing from 4000 to 5000 tons per month. The ore is concentrated, roasted in reverberatory furnaces, and then smelted in Freiberg furnaces. In 1884 the average monthly yield was 1000 lbs. of auriferous silver and 25 lbs. of gold, worth $40,000. At present the monthly output is from $60,000 to $70,000. In 1852 an English company bought the Frontino mine and several veins called Bolivia at Remedios. After many failures due to mismanagement the company succeeded in getting on a profitable basis, and it is now one of the most important in the country.

Dr. F. Pereira Gamba, of Bogotá, has communicated the following on the production of gold and silver during 1891: "The output of the principal gold-mining companies during 1891 was as follows: Frontino and Bolivia Mining Company, $420,000; Colombian Mining Corporation, Limited, $64,000; Echandia mines, $240,000; Constancia mine, $50,000; Marmato mines, $60,000; Supia and Rio Sucio mines, $80,000; and the Mariquita and Fresno mines, $400,000. The Zancudo silver mine produced bullion valued at $780,000; the Frias mine, belonging to the Tolima Mining Company, $768,000. The total output of gold was 4864 kilograms, valued at $3,232,500, and divided among the following States: Antioquia, 2660 kilos; Cauca, 1024 kilos; Tolima, 1044 kilos; Panama, 60 kilos; Santander, 45 kilos; and Bolivar, 30 kilos. Of the whole amount about 60% was alluvial. The total output of silver was valued at $1,806,000, of which $780,000 was from the Zancudo mine, in Antioquia, and $768,000 from the Frias mine, in Tolima."

Geology.—In Antioquia and Cauca the veins occur, according to Boussingault, in syenitic and porphyritic "grünstein."

Mr. John C. F. Randolph says that the geology of Colombia is very simple, and in many respects similar to that of the western part of the United States.*

"On the Tolima side the alluvial formation is cut through by red Triassic sandstone. At a height of 4000 to 5000 ft. a zone of Archæan schist is encountered, consisting at various points of micaceous, chloritic, talcose, hornblendic, or silice-

* *Transactions American Institute Mining Engineers*, 1889–90, p. 208.

ous varieties. These schists all coincide in strike with that of the range, and dip to the east. They are the oldest rocks known in Tolima, and are probably of Laurentian or Huronian age. They have been exposed by the breaking of the overlying Triassic formation at the time of the upheaval of the central range, and are cut through continually by dikes of andesite and other eruptive rocks. At some points the Triassic sandstones are overlaid with thin patches of Jurassic limestone. It is therefore probable that the elevation of the Central Cordillera took place either at the end of the Triassic or at the beginning of Jurassic time. Subsequently occurred the action of the great forces of erosion in the Quaternary, producing the alluvion and gold-bearing gravels of Tolima. The same geological features are attested by competent observers as extending northward through the State of Antioquia, and are found on the west of the range. On the east side of the Magdalena River the Eastern Cordillera rises rapidly to Bogota. The same geology is encountered, except that the Jurassic limestones are found of very great thickness overlying the Triassic sandstones. In the Triassic formation abundant lean lignites and black asphaltic oils are found, as well as some evidences of copper. In the black Jurassic limestone of Boyaca are the celebrated emerald mines of Muzo. In that division of the Archæan schists which consists of mica-schist, veins are occasionally found containing free gold, as at Ibague, Bermillion, and Aneime, and in the silico-chloritic class of schists veins carrying ruby and black silver. Galena is notably rare in Tolima and other departments of Colombia."

Platinum.—Colombia was for many years (1735 to 1823) the sole source of this metal. It is found in Antioquia, Barbacoas, and El Choco, but in the last alone is its occurrence of economic importance.* Platinum occurs with gold in varying proportions in alluvial deposits and in the beds of the rivers tributary to the San Juan and Atrato rivers. The beds of the San Juan, Mungarrá, Iro, Condoto, and Tamaná rivers are especially rich in this metal. Formerly the mines belonged to two great Colombian families, the Mosqueras and Arboledas, who worked them with slaves. During this period (1800 to 1850) the production was much larger than at present, varying from 200 to 500 kilos of platinum and from 500 to 1500 kilos of gold annually. When slavery was abolished the production rapidly decreased, and about 1855 the Mosqueras and Arboledas abandoned the mines to their former slaves. Since 1880 the output has been about 125 kilos per annum. It is estimated, from all the data obtainable, that the total production from 1740 to 1892 is from 16,000 to 20,000 kilos, worth from $1,280,000 to $1,600,000.

Emeralds.—The emerald mines of Muzo, about 75 miles from Bogota, the capital of Colombia, and classed by all writers on gems as the most famous mines in the world, were discovered by Lanchero in 1555. Work was commenced in 1568, and although no exact data are to be obtained, it is known that for many years the output of fine stones was so great that they ceased to be rare. The mines were abandoned about 1740, and so remained until 1844, when they were reopened by Señor Paris of Bogota. Soon afterward a French company was formed, and the mines were leased from the Government at an annual rental of $8000. This company sent many fine stones to Paris; but the work evidently did not pay, for the mines were abandoned in 1868. They are now leased by a company paying $24,000 annually, the lease to run until 1896.

The gems are found in a bituminous limestone said to be of Lower Cretaceous

* For a more extended account of the occurrence of this metal in Colombia, see "Platinum," p. 126.

age which lies upon red sandstone (Triassic) and clay-slate. The emeralds occur either in isolated crystals or in geodes with calcite, iron pyrites, and parisite. Streeter * describes the great Muzo mine and method of working as follows:

"The mine has the form of a tunnel about 100 yds. deep, with very inclined walls. Near the mouth are several large reservoirs whose waters are shut off by gates. The overlying barren rock is cut out in benches and falls to the bottom of the tunnel. When this begins to fill, the water is turned on and the rock is carried away through an underground tunnel into a basin below. This operation is repeated until the stratum containing the gems is laid bare."

Coal.—At least three beds of coal of considerable extent are known to occur in Colombia. The Cali bed, in the Department of Cauca, may eventually prove of considerable importance if the projected railroad from Buenaventura to Cali, or the Intercontinental road, is ever finished. This road, which was started 20 years ago, and which is needed to give a cheap outlet to the products of the Cauca Valley, has less than 20 miles completed and in working order. Small quantities of the Cali coal have been tried on the road with good success, the chief engineer informing me in 1890 that its steaming qualities were excellent. *Iron* mines occur in the vicinity of this coal, but as yet neither is worked. At Punta de Piedra de Uraba, on the northern coast of Cauca, there is a deposit of coal which is said to extend some 18 leagues from north to south, with a thickness of 5 to 6 meters. At Arboletes, near the Uraba deposits, there is a bed of lignite of considerable extent.

The following analyses of these coals were published in the *Revista de Minas*, Bogota, 1888:

	Arboletes, Lignite.	Uraba, Anthracite
Specific gravity	1.56	1.79
Fixed carbon	39.85	78.00
Volatile	51.80	13.66
Ash	8.35	8.34

A concession for working these deposits was granted by the Government in 1886 to Mr. Jorge Isaacs. This concession, which expired by limitation in 1888, has been several times renewed, and now runs to Dec. 31, 1893.

In the Department of Magdalena coal is found near the river Aracataca, and it is reported that a company has been formed to work it.

Salt.—The mining of salt is a Government monopoly, the revenue from it being one of the principal sources of the national income. The most important beds of rock salt are situated in the Departments of Cundinamarca and Boyacá, while many salt springs exist in Antioquia, Cauca, and Tolima.

PRODUCTION OF SALT IN COLOMBIA DURING 1890 AND 1891.

Year.	Rock Salt.	Evaporated Coarse.	Evaporated Fine.	Total.	Gross Value.	Cost.
	Tons.	Tons.	Tons.	Tons.		
1890*a*	11,509	2,483	2,567	16,559	$1,228,450	$283,417
1891*b*	16,808	2,836	2,000	21,644	979,336	269,195

(*a*) In 1890 there was imported at Buenaventura 2585 tons of salt from Peru, which paid a duty of $64,626. There was also imported 368 tons of Peruvian salt at Tumaco, which paid a duty of $9210. Besides the above given production, a small amount of salt was obtained from the salt wells of Gachetá, which the Government leased for $6500. The dollar of this table is the peso, weighing 25 grams and 900 fine.

(*b*) In 1891 the imports of Peruvian salt at Buenaventura amounted to 1477 tons, which paid a duty of $36,935. The imports at Tumaco were 616 tons, paying a duty of $15,403. The leased salt wells of Gachetá paid for the first 8 months of the year $4333, at which time the Government took up the lease and produced salt worth $1141.

* *Precious Stones and Gems.* 1892.

Peru.

Peru, next to Bolivia, has been the greatest producer of silver of the South American countries, and is celebrated for the enormous yield of one mine, the Cerro de Pasco. This mine, which it is said was accidentally discovered by an Indian in 1630, has been worked almost continuously for 260 years, and is still producing at the rate of 1,000,000 oz. of silver per year. Until 1780 the mines were worked with little or no drainage, but in that year the socavon (drainage tunnel) of San Judas was commenced. When finished, in 1800, it was 3500 ft. long, and 5.5 × 6.9 ft. In 1806 the great tunnel of Quiulacocha was begun, but as originally planned was never finished. In 1825 an English company, called the Pasco Peruvian, undertook the drainage, but failed two years later. In 1847 the Gremio governing the mine contracted with Mr. Jump, an American, to drain the mine by steam-power, and much good work was done by him.

Almost the only ores worked up to this time were the *pacos*—ferruginous earths mixed with silver ores, and resulting from the oxidation of argentiferous sulphides. Of the more recent history of this mine, Mr. E. E. Olcott, mining engineer, of New York, writes that the property was thoroughly explored in 1886–87, in the interest of an American syndicate formed by prominent New Yorkers. The syndicate has done nothing further to develop the mining interests. During the time of Henry Meiggs a contract was made for running the Rumillana tunnel, which would tap and unwater the Cerro de Pasco mine 150 ft. below the level now being worked. As it is computed that from 250,000,000 to 400,000,000 oz. of silver have been extracted in the last 300 years from the Cerro de Pasco (all within the first 300 ft. below the surface), it is probable that large bodies of rich ore can still be developed. Probably the largest body of low-grade silver ore in the world is now standing exposed at the Cerro de Pasco, but it cannot be profitably worked with the present facilities and at the present low price of silver. The annual product of this mine is about 1,000,000 oz. of silver, wholly extracted by the crude native systems of grinding in large Chilean mills and amalgamating in patio.

There is a small mineral railway running out from the Cerro de Pasco toward some of the haciendas; but the ore has to be transported at both ends of the line on llamas, so that now some of the principal proprietors have discontinued shipping by the railroad. In consequence of this the railroad, which is controlled by the English bondholders, is not making expenses. The proximity of very large beds of coal and notable deposits of salt, as also the possibility of developing a good water-power within 20 miles of the Cerro, point to the possibility of the installation of works of magnitude. It is probable that this town will within a few years be reached by the Central Railroad of Peru (the distance from Oroya being only from 90 to 100 kilometers), and this would give a great impulse to all plans for its exploitation.

The yield of this mine from 1630 to 1849 was, according to Castelnau, about $475,000,000, equal to 1,144,000 kilos of fine silver.

Humboldt estimated the production from 1630 to 1792 at 274,400,000 pesos, and from 1792 to 1803 at 24,901,000 pesos—a total of 299,301,000 pesos. Mr. William R. Grace gives the yield from 1784 to 1878 as follows:

SILVER PRODUCTION OF CERRO DE PASCO.*

Year.	Kilos.	Dollars.	Year.	Kilos.	Dollars.	Year.	Kilos.	Dollars.	Year.	Kilos.	Dollars.
1784....	15,687	650,530	1808 .	55,960	2,320,630	1832....	50,457	2,092,500	1856....	50,223	2,082,750
1785 ..	16,895	700,630	1809....	65,730	2,725,810	1833....	59,127	2,451,950	1857....	46,279	1,919,150
1786....	25.093	1,040,620	1810....	55,250	2,291,250	1834....	61,440	2,547,900	1858....	46,651	1,934,600
1787....	23,267	964,880	1811....	58,804	2,397,150	1835....	63,651	2,639,600	1859....	46,796	1.940.650
1788....	27,612	1,145,050	1812....	41,414	1,717,450	1836....	56,213	2,331,100	1860....	44,701	1,853,750
1789 ...	27,924	1,158,030	1813 ...	41,607	1,725,470	1837....	54,257	2,250,050	1861....	53,556	2,221,000
1790....	27,140	1.125,500	1814....	44,223	1,833,900	1838....	57,949	2,399,250	1862....	46,345	1,291,900
1791...	28,475	1,180,820	1815....	36,046	1,494,800	1839....	64,313	2,667,100	1863....	47,033	1,950,450
1792....	42,228	1,751,200	1816....	41,400	1,716,870	1840....	70,659	2,930,200	1864....	51,476	2,134.750
1793 ..	53,933	2,236,600	1817....	33,785	1,399,200	1841....	91,108	3,778,300	1865 ...	40,268	1,669,950
1794 ...	66,987	2,778,000	1818 ...	38,532	1,595,800	1842....	89,222	3,700,000	1866....	49,964	2,072,000
1795 ...	64.312	2,668,280	1819 ...	43,800	1,856,150	1843	74,856	3,104.300	1867....	47,210	1,957,800
1796....	63,837	2,647,320	1820....	71,974	2,980,750	1844....	63,159	2,619,200	1868...	49,964	2,072,000
1797....	55,879	2.317,300	1821... .	*a*	*a*	1845. ..	57.740	2,394.450	1869....	48,059	1.993,000
1798....	62.528	2,593,050	1822 ..	*a*	*a*	1846....	64,633	2,680,300	1870....	46.893	1,940,150
1799 ...	52.524	2,178,150	1823....	*a*	*a*	1847....	56,422	2,339,800	1871...	46,072	1,910,600
1800....	64,740	2,684,800	1824 ...	*a*	*a*	1848....	62.790	2,608,900	1872....	46,244	1,917,750
1801....	54.614	2,264,620	1825.. .	*a*	*a*	1849..	52,875	2.192,750	1873 ...	42,170	1,748.800
1802 ..	60,700	2.517.250	1826....	38,208	1,584,480	1850....	52.796	2,189,500	1874...	40,927	1,697,200
1803 ..	65,134	2,701,110	1827....	50,945	2,112,700	1851....	58,352	2,419.850	1875. ..	39,027	1,618,430
1804....	73,718	3.057,170	1828....	46,318	1,921,270	1852....	50,270	2,084,650	1876....	39,073	1,620,330
1805 ...	70,392	2,919,150	1829 ..	22,963	952.240	1853....	66.337	2,750,950	1877....	41,044	1,702,500
1806 ...	37.074	1,537,470	1830....	22,830	946,770	1854 ...	46.621	1,933.370	1878...	36,715	1,522,570
1807. ..	55,667	2,308,520	1831 ...	35,680	1.479,680	1855....	59,325	2,460.150			

* Since 1878 exact returns are not obtainable, but it is known that the production rapidly decreased for a number of years, and that since 1885 it has increased, and is now about 33,000 kilos per annum.
(*a*) War of Independence.

The most important of the other silver-producing districts of Peru are Huantajaya, Hualgayoc, and Chota.

Gold.—Of late years the gold output of Peru has greatly fallen off, and at present does not amount to more than 120 kilos per annum. Many of the departments of the republic are auriferous. The mines of Cuzco are said to be those from which the Incas mined the gold to ransom their king, and of these one mine, the Inca Caucha, is said to have yielded $3,000,000 since the conquest. In Puno the mines of Carabaya and Sandia have produced large amounts of gold, and at the latter place Don Manuel Peña now has a hydraulic plant—the only one in the country.

The Nueva California district, to the east of Chala, is said by competent American engineers to possess all the essentials for large and successful work. From the conquest to the present time Peru has produced 32,199,263 kilos of silver, worth $1,335,303,400, and 166,689 kilos of gold, worth $110,781,500.

Quicksilver.—Ores of mercury are abundant, but the mines have been abandoned or only spasmodically worked for a number of years. The most celebrated of the mines is that of Huancavelica, which was discovered in 1570, and up to 1790 yielded, according to Castelnau, 104,045,200 lbs. of metal, worth $67,629,380, upon a gross expenditure of $10,587,000. The discovery of this great mine was of the utmost economic importance, as it rendered possible the enormous output of the Cerro de Pasco and Cerro Potosi silver mines.

Copper.—There are numerous copper mines in Peru, but none are important. The production in tons since 1883 has been as follows: 1883, 401; 1884, 367; 1885, 232; 1886, 76; 1887, 50; 1888, 253; 1889, 279; 1890, 152.

Guano.—The most celebrated of the guano deposits of Peru are those of the Chincha Islands, to which attention was first called by Humboldt in 1804, but which were left unworked until Liebig's researches in agricultural chemistry proved the great value of artificial fertilizers. In 1840 a small cargo was sent to England, and in 1842 guano became a regular article of export. In 1873, after the exportation of nearly 14,000,000 tons, the deposits were exhausted. The price varied from $45 to $70 per ton.

From 1870 to 1880 the Macabi and Huanape Islands furnished about 1,300,000 tons, but the quality was inferior to that of the Chinchas. About 1875 attention was turned to the deposits of Tarapaca and the adjacent islands, and it was estimated that the deposits of Pabellon de Pica, Huanillos, Punta de Lobos, and Lobos Island contained 1,500,000 tons of merchantable guano. In 1879 Chile took the Province of Tarapaca by force of arms, and by the treaty of Ancon in 1883 the Lobos Islands were ceded to her.

Concerning the present status of the guano trade of Peru, Mr. E. E. Olcott writes as follows:

"By the Treaty of Ancon, in 1883, Chile acquired the right to occupy the Lobos Islands until such time as she should have exhausted the guano deposits, which she agreed to work on joint account with Peru's foreign creditors. At the time of the settlement with the Peruvian bondholders and the formation of the Peruvian Corporation, Limited, Chile, under pressure from France, Holland, and Great Britain, agreed to cede these rights to Peru 'in order to enable her to satisfy her creditors.' It was thus that the last-mentioned Government was able to promise the bondholders 2,000,000 tons of guano, among the other considerations given them, in exchange for the surrender of £32,000,000 in five or six per cent obligations, now lying deposited in the banking-house of Robarts, Lubbock & Co., London. Chile in fact not only promised to hand over all the guano deposits in her possession, and the amount lying in the Bank of England, as resulting from the half share above mentioned, but to make a further payment of about £1,800,000. The latter amount was the estimated profit which had accrued to Chile since the signature of the Treaty of Ancon. The Peruvian Corporation at once commenced shipments, but owing to certain claims made by Messrs. Dreyfus & Co. of Paris, and perhaps other reasons, Chile has not yet handed over the Lobos deposits; consequently the corporation was compelled to resort to the smaller islands. The quality thence obtained was equal to the Chincha, and sold well, but the cost in such small deposits is considerably heavier than in the larger ones. The Peruvian Corporation in its report of June, 1892, estimated the profit on guano sold by it in the twelve months at £130,000." Official figures for the last half of 1892 show that 17,091 tons have been shipped during that period.

Petroleum.—The presence of *copé*, or asphaltum, in the Department of Piura has been known for more than a century, and it was used to coat the insides of earthen water-jugs. About 1860 petroleum was discovered in the asphaltum beds of Mancora and Zorritos, and later on expensive works were established at Negritos to refine the oil. This attempt failed, as did likewise one started about 1865. In 1876 Mr. Prentice, who was interested in Pennsylvania oil-wells, sunk a well 500 ft. deep at Tumbez, and, getting a good supply of oil, asked the Peruvian Government to grant him a concession of the entire petroleum district. This the Government refused to do, and in 1880 Mr. Piaggio acquired control of the hacienda de Mancora, and established there the first refining-works in South America.

In 1887 Mr. Herbert W. C. Tweddle, an American, purchased the hacienda of Pariñas, and established at Talara very large refining-works, now owned by the London and Pacific Petroleum Company.

The petroleum beds of Peru have an area of about 16,000 sq. miles. The oil is found in slate at a depth of 200 to 500 ft., the overlying materials being: 1. At the surface a layer of sand from 0.25 to 4 meters thick. 2. White sandstone

from 0.3 to 2 meters thick. 3. A layer of wet sand from 8 to 10 meters thick. 4. A conglomerate of sea-shells from 5 to 10 meters thick.

The oil is similar to Pennsylvania oil, except that it contains little or no paraffine. On the west coast of South America it has entirely replaced American kerosene, and its use is rapidly extending. The crude oil has been tried on the Oroya Railway, and, according to a report by Mr. F. Moreno, the Peruvian Corporation has made contracts for a regular supply of the oil for its railways.

But few exact figures of the early production can be obtained. The first gallon of kerosene was produced at Zorritos in 1881, and in 1885 the output, according to Moreno, was 300,000 barrels. The production since 1885 has been as follows:

PETROLEUM AT ZORRITOS, PROVINCE OF TUMBES.*

Year.	Petroleum, Crude. Kilos.	Kerosene, Kilos.	Lubricating Oil, Dark. Kilos.	Lubricating Oil, Light. Kilos.	Benzine, Kilos.	Tar, Kilos.
1885	776,185	318,691	272,160	24,570	5,405	13,608
1886	1,002,622	505,386	409,472	30,066	21,054	11,718
1887	1,104,928	575,580	378,423	27,783	22,415	12,285
1888	2,132,789	989,755	492,348	78,397	19,656	19,650
1889	2,151,874	999,658	457,799	69,363	18,937	3,780
1890	2,324,219	1,199,161	1,115,667	81,270	1,890	17,766
1891 (5 months)	552,000	541,220	110,232	25,893	1,890	1,890
Total	10,024,617	5,129,451	3,236,101	337,342	91,247	80,703
TALARA, PROVINCE OF PAYTA.†						
1890	1,113,500	2,003,327	91,245		....	....

* From *Memorias del Ministro de Hacienda.*

† The custom-house was opened in the latter part of the year. The export of petroleum products for the first three months of 1891 was greater than for the previous year.

Peruvian Corporation, Limited.—Of this company, formed to relieve Peru from the overburdening weight of debt, Mr. E. E. Olcott writes as follows:

"In 1890 the bondholders relinquished £32,000,000 of old Peruvian bonds, on which no interest had been paid since 1875; they are now deposited with Messrs. Robart, Lubbock & Co., in London, and are being canceled. They are absolutely wiped out, so far as any claim against Peru is concerned, but they are still held over Chile's head. The old bondholders received stock in the Peruvian Corporation, Limited (organized by Mr. M. P. Grace), as follows: For the 6% bonds of 1875, 25% of the amount in 4% preference stock, 30% in ordinary shares, and an asset receipt against the amount held in the Bank of England under the Chilean settlement for £3 for each per cent; that is, for every £100 in Peruvian bonds the holder could get £3 when the Chilean money in the Bank of England is divided.

"The holders of 5% Peruvian bonds of 1872 received 20% of the amount in 4% preference stock in the Peruvian Corporation, Limited, 25% in ordinary shares, and £2½ per each per cent in asset receipts.

"Last year, 1891, the preference stock received 1%, and as the preference for four per cents is cumulative, it now has to get 7% before the common stock gets anything. Peru gave to the Peruvian Corporation, Limited, all the railways for 66 years; 2,000,000 tons of guano, which Chile had allowed Peru, under the Treaty of Ancon, 1883; immense tracts of land in the interior; and a payment of £80,000 per annum, commencing Jan. 1, 1893.

"In 1891 the Peruvian Corporation, Limited, claims to have made in the railways alone a profit of £180,000. The southern road, from Mollendo to Puno, now completed to within 75 miles of Cuzco, is especially profitable, and the Oroya or Central road, from Callao, is also doing well."

Uruguay.

Mining in Uruguay, the smallest of the South American republics, is limited to the production of a small amount of gold, paving and building stone, and agate.

Gold.—In 1879 the first gold-mining company in Uruguay was incorporated with French capital to work certain veins in the Province of Minas, but the company failed to find paying ore, and abandoned the enterprise a few years later, after the expenditure of a considerable amount of money. In 1884 a second company was formed, also with French capital, and it also failed to find good ore. In 1885 the Sociedad General de Minas de Oro del Uruguay was incorporated, and after a precarious existence for a number of years succeeded in finding ore of fair quality. Since 1885 two other companies have been formed, namely, the Gold-fields of Uruguay, Limited, in 1888, and the Hermanos Gold-mining Company, in 1890. According to the American consul, Mr. F. D. Hill, these three companies worked during 1892 about 100 stamps, crushing 200 tons of ore daily.

Of these companies the most important is the Gold-fields of Uruguay, working the San Gregorio mine, near Cunapaira, in Tacuaremba. During the year ending May 31, 1890, it crushed 25,070 tons of ore, yielding 2765 oz. of gold, valued at $57,159, an average of $2.28 per ton; during 1891 it crushed 32,192 tons, yielding 3301 oz. of gold, worth $68,247, an average of $2.12 per ton; and during 1892 29,300 tons, yielding 3317 oz. of gold, worth $68,568, an average of $2.34 per ton. During the first four months of 1892 the ore averaged $4.10 per ton, but since then has fallen to about $3.10. The total production of fine gold since 1885 has been as follows:

PRODUCTION OF GOLD IN URUGUAY.*

Years.	Ore Crushed, Tons.	Gold, Kilos.	Years.	Ore Crushed, Tons.	Gold, Kilos.
1885	3,227	64.28	1889	17,804	139.26
1886	5,489	85.01	1890	29,000	187.00
1887	3,767	63.91	1891	......	140.00
1888	2,030	25.73	1892	....	160.00

Stone and Building Material.—Besides the stone, lime, sand, etc., required for use in the country, a considerable amount of these materials is annually produced for exportation to the Argentine Republic. In 1890 the exports were as follows: Sand, 276,107 tons, value $276,107; gravel, 38 tons, value $38; lime, 398 hectoliters, value $80; paving-stone of all kinds, $616,149; limestone, 4644 tons, value $13,183—making a total of $905,556. To this should be added 301,482 kilos of agate, valued at $30,148, and 9945 tons of guano, valued at $203,916.

During 1891 the exports to the Argentine Republic fell off, but not to a great extent. Uruguay has a larger railway mileage, compared with her area, than any other country of South America, having at the beginning of 1892 about 1571 kilometers of road in operation, and an area of 63,330 square miles.

* The figures from 1885 to 1890 are official. The output for 1891 is taken from the Report of the Director of the United States Mint, and that for 1892 is estimated from the returns of the Gold-fields of Uruguay, Limited.

Venezuela.

This country has become celebrated through the yield of a single mine, namely, El Callao, in the El Caratal district of the Territorio Yuruari. Since 1869 this mine has produced 1,382,268 oz. of gold 912 fine, or 39,210.8 kilograms of refined gold, from which the company has paid $9,666,440 in dividends.

Since 1887 the average yield per ton has rapidly decreased, and in 1892 the output barely paid its expenses. Recent advices state that the prospects are growing still worse, that the stopes of fairly rich ore are becoming exhausted, and that no new bodies of paying ore have been opened. In a recent report (Dec. 5, 1892) Mr. Webber, the superintendent, advised robbing the pillars and ultimately abandoning the property. Signor Liccioni, president of the company, has not yet given his consent to this last resource, believing it best to preserve the good condition of the underground workings, and thus permit a new company to raise capital for further exploration.

There are a number of other mines in this district, most prominent among which are the Callao Bis, Chile, and La Union, worked by English companies; but none of them are of much importance. To the east and south of El Caratal there is a large district, which contains many gold-placer deposits of value, and over which sovereignty is claimed by both Venezuela and Great Britain.* The disputed territory is included between the Yuruari and Cuyuni rivers on the west and south, the Essequibo and Barima on the east, and the Orinoco on the north. At present this section is producing from 8000 to 10,000 oz. of gold per month, all of which passes through Georgetown, English Guiana. Formerly some gold was obtained from the placers near Valencia, but the amount was never important.

The most important silver mines of Venezuela are the argentiferous lead mines of Carupano, which have been worked spasmodically for many years, but so far with little success. Silver is found in the States of Bermudez, Lara, and Los Andes.

Venezuela ranks eighth among the copper-producing countries of the world. This is due to the output of a single company, the Quebrada Railway, Land, and Copper Company, Limited, which owns the mines of Aroa in the Yaracuay district of the State of Lara. The copper mines of Guzman Blanco and Bolivar are not now worked. Some years ago (1886) several mines were opened in the neighborhood of Esperanza, and some 45 to 50 tons of ore and regulus were shipped from Puerto Cabello, but owing to lack of transportation facilities they were forced to close down.

Important deposits of iron ore occur in Venezuelan Guiana, on an island in the Delta Orinoco. In 1887 an American company prospected the depcsit and a few small cargoes were shipped, but so far as can be ascertained the mines are not now worked.

Asphalt and petroleum occur in considerable quantity in the delta of the Orinoco, and at Tachira, but no use has been made of them. The Orinoco deposits of asphalt are similar to the Trinidad deposits, and it is believed that they will eventually form a valuable source of supply.

At Barcelona there are large outcrops of coal of good quality. From time to time various companies have been formed to work them, the latest being a French

*_Engineering and Mining Journal_, March 24, 1888.

company known as the Hullas del Neveri. No statistics of production are obtainable, but the amount is known to be small.

The principal salt mines of Venezuela are: Araya, worked by the Spaniards in the last years of the fifteenth century, and Guanache, both in Bermudez; Coche Island, in the Nueva Esparta section in the State of Guzman Blanco; Mitare and Guarano, in the same State; and La Hoyada, Sabaneta, and Salina Rica, in the State of Falcon. From 1883 to 1886 these mines were worked by contract, but since then they have been worked by the Government. Large but low-grade deposits of phosphate of lime occur in many of the islands of the Territorio Colon. The most important of these is Orchila, from which there have been shipped about 50,000 tons of phosphate, worth from $7 to $12 per ton.

From Aves Barlovento and Aves Sotavento some 10,000 tons, worth about $19 per ton, have been shipped to Europe, and a like quantity, worth $10 per ton, to the United States. The deposits of Los Testigos, Los Roques, and Las Monas are quite extensive, but of too low a percentage of phosphoric acid to be profitably shipped at present prices. The present annual shipments of phosphate from all the Venezuelan islands do not amount to more than 1800 tons, worth about $18,000.

The mining law now in force was adopted June 30, 1891. This law provides for the granting of concessions of not less than 1 hectare nor more than 200 for periods of not less than 50 nor more than 99 years. Any person who discovers a vein is entitled to a concession, subject to a tax of 2% on the gross yield of the mine. Section 71, Title VIII., provides for the free importation of mining machinery. Several of the provisions of this law are irksome and should be repealed, especially those providing a penalty of $2000 if work be abandoned for two years, and a penalty of $800 to $2400 if the books of the company are not kept in the Spanish language.

MINERAL PRODUCTION OF VENEZUELA.

Year.	Copper.		Gold.			Salt.
	Metric Tons.	Value.	Ounces.	Kilos.	Value.	
1866	....	....	15,587	484.9	$293,755	Government revenues derived from salt industry. The average price is $.005 per kilogram.
1867	....	....	30,142	937.8	568,061	
1868	....	....	29,050	903.8	547,481	
1869	....	....	33,554	1,044.0	632,357	
1870	....	....	35,713	1,111.1	673,067	
1871	....	....	25,941	807.0	488,888	
1872	....	....	33,747	1,019.0	617,159	
1873	....	....	41,609	1,294.6	784,169	
1874	....	....	55,698	1,733.0	1,049,693	$80,461
1875	....	....	79,497	2,473.4	1,498,212	185.011
1876	....	....	86,530	2,692.0	1,630,750	140,838
1877	....	....	100,989	3,142.2	1,903,062	195,680
1878	1,294.1	$470,534*	95,204	2,962.2	1,796,152	113,042
1879	1,944.5	733,854	107,722	3,351.6	2,030,145	82,496
1880	2,263.2	1,003,729	116,798	3,634.0	2,201,193	179,258
1881	2,784.6	1,112,447	118,780	3,695.9	2,238,546	225,831
1882	3,882.2	1,582,772	138,607	4,312.6	2,612,210	200,633
1883	4,103.0	1,435,228	179,107	5,572.7	3,375,477	201,518
1884	4,554.2	1,392,674	233,935	7,278.6	4,408,782	116,666
1885	4,679.3	1,147,364	173,501	5,398.2	3,269,826	108.333
1886	3,790.0	842,896	233,794	7,272.0	4,628,908	113,333
1887	3,191.5	727,342	87,758	2,730.5	1,649.850	120,699
1888	4,576.0	1,680,764	75,349	2,344.4	1,416,561	182,030
1889	5,736.7	1,738,496	88,867	2,765.0	1,838,000	....
1890	5,622.0	1,951,564	80,635	2,512†	1,670,000	....
1891	6,356	....	48,338	1,504†	1.000,000	....
1892	3,021‡	....	64,300	2,000§	1.204,625	....

* These values are estimated on the basis of the average price of refined copper for the several years.

† United States Mint reports.

‡ The falling off from the production of 1891 is due primarily to six months' stoppage of work consequent upon the revolution of Joaquin Crespo, and secondly to severe floods which impeded work.

§ Estimated. The El Callao for 9 months in the year yielded 26,553 oz., against 34,774 oz. in 1891. The Callao Bis yielded for 10 months 10,532 oz.

SPAIN.

By Roman Oriol, Professor at the School of Mines at Madrid.

The year 1892 was one of but moderate prosperity for the Spanish mineral industry, owing to causes enumerated as follows:

Import Tariffs.—The denunciation of the commercial treaties has greatly affected general business in Spain, and the necessity of assuming a defensive *rôle* in the negotiation of new treaties forced the Spanish Government to publish in haste, on Dec. 31, 1891, a new tariff schedule, which has been in force since Feb. 1, 1892. The ultra-protectionist spirit which animates it is a great obstacle to the development of Spanish industry. Some of the duties are shown in the following table:

SPANISH IMPORT DUTIES PER METRIC TON (2204.6 lbs.).
Calculated in dollars at the rate of 5 pesetas to $1.

Article.	For Nations without Special Treaties. $	For Nations under Special Agreement. $	Article.	For Nations without Special Treaties. $	For Nations under Special Agreement. $
Coal	.60	.50	Nails—wire, iron, and steel	28.80	24.00
Tar, pitch, etc	1.20	.80	Tin plate	48.00	40.00
Petroleum, crude	50.00	50.00	Copper, first fusion	54.00	45.00
" refined	80.00	80.00	" tubes	139.40	111.60
Marble, polished	4.00	3.50	Tin, ingots	30.00	25.00
Window-glass	48.00	40.00	Agricultural machines	36.40	28.00
Pig-iron	4.80	4.00	Locomotives	67.20	56.00
Cast-iron pipes	12.00	10.00	Motive machines	43.20	36.00
" " less than 10 mm. diameter	19.20	16.00	Galena	2.50	2.50
Iron and steel rails	14.00	12.00	Argentiferous lead (with more than 300 g. Ag to the ton)	2.00	2.00
Iron, bar	22.80	19.50	Argentiferous litharge	3.00	3.00

In the general estimates approved by the Cortes on June 30, 1892, which amount to a total revenue of $149,592,110 and a total expenditure of $158,442,-562, the mining industry is estimated to produce from taxes on mines, 4,000,000 pesetas; taxes on salaries of the personnel, 100,000 ; salt mines of Torreveija, 1,500,000; Almaden mines, 8,600,000; Arrayanes de Linares mine, 2,000,000; tax on the consumption and transportation of minerals, and stamps (approximately), 1,800,000; or a total income of $3,600,000; while the expenditures for the mineral industry are estimated at a total of $678,580, or 3,392,900 pesetas. Consequently the mining industry of Spain returns to the Government the net sum of 14,500,000 pesetas, or $2,900,000, annually.

The increased taxes placed upon this industry since July 1, 1892, are a heavy burden. The former tax of 1% on the gross product of mines has been doubled, and the fee, according to surface area, which all mines pay (4 pesetas per hectare for coal and iron mines and 10 pesetas for other metalliferous mines) has been increased by 30%. These increases have exerted a fatal influence upon mining. During the second half of 1892 many unproductive mines have been given up which formerly paid their taxes in the hope of better times, and productive mines have suffered by the increase, heavily handicapped as they were already by the general crisis in the metal markets.

In spite of what I said in the *Engineering and Mining Journal* of Jan. 2, 1892, the Bureau of Mining Statistics of Spain has not yet published any data later

than 1888. This delay of four years in making public the statistics of mineral production deprives the bulky volumes of the bureau of all interest, and when they are issued it leaves to them only their historical importance. It is just at times such as this that statistics are of the greatest value. The general crisis in the metal market on one side, and on the other the situation created by the denunciation of the commercial treaties and the reform of the tariff, render it imperative for all interested to observe those changes in the mining and metallurgical production which timely statistics would show. With this object in view I have deemed it my duty to seek to offset the deficiency of the official service by asking directly of the engineers, miners, and smelters for the data necessary to compile this statistical review, and I take this opportunity to express my gratitude to all those who have facilitated this useful work.

Bituminous Coal.—Two important events took place in 1892 tending to the development of the bituminous basins in the north of Spain—the selling by auction of the port of the Musel, and the opening of the railroad from Robla to Valmaseda. The works of the port of the Musel are indispensable to the convenient shipment of Asturian coals. They were adjudged last April to Don Lazaro Ballesteros for the sum of 10,596,348 pesetas ($2,119,269.60) and are being carried forward with considerable activity, but their very importance will retard their completion. In the mean time the old harbor of Gijon is being improved in order to meet the growing requirements of the bituminous-coal industry.

The exploitation of the Asturian coal mines is progressing slowly. The completion of the railroad from Soto del Rey to Ciaño-Santa Ana in 1894 will develop the mines of the valley of Sama de Langreo. The principal producers of bituminous coal in Asturias, shipping more than 100,000 tons annually, are the Fabrica de Mieres Company, the Union Huillera y Metalurgica de Asturias, and the Marquis of Comillas (Aller mines).

In the Province of Leon there have been worked hitherto only a few mines in Ciñera and Pola de Gordon, near the railroad from Leon to Gijon. M. Iglesias & Co. produced 5365 tons in 1891; in 1892 their output reached 9356 tons, owing to the introduction of sorting screens. The new washery and the plant for the manufacture of briquettes will bring about a further increase in the output for 1893. The Santa Lucia mine of Pola de Gordon is the only anthracite mine in Spain which has been prepared for regular working in 1892.

The railroad from La Robla to Valmaseda is essentially a mining road. It commences at La Robla (Leon), on the line of the Leon and Gijon road, and will cross the bituminous basins of Matallana, Sabero, and Valderrueda, in Leon, as well as the basins of Guardo, Cervera de Rio Pisuerga, San Cebrian de Muda, and Orbo, in Palencia. It will cross at Mataporquera the line from Palencia to Santander, and in the northern part of Burgos it will reach Valmaseda, in Biscay, connecting with the narrow-gauge railroad from Valmaseda to Bilbao, and thus will be enabled to supply the important iron establishments of the last-named city. The line is 270 kilometers long, of which 45 kilometers on the Valmaseda end and 31 kilometers at La Robla were opened in 1892. The work continues along the rest of the line, the gauge of which is one meter. The miners have already commenced explorations in the basins of Matallana and Sabero. In the Matallana basin there has been introduced an Evrard washer for nut coal, and

a set of Bernard coke ovens is being finished. It is expected that by the spring of 1893 a Humboldt washer of 200 tons' daily capacity will be erected for the smaller sizes. The active exploitation of the Matallana coals will also commence next spring. Another company from Bilbao is about to begin work on a large scale in the Sabero basin, and will supply the Bilbao establishments with fuel. In Palencia the San Cebrian de Muda basin is being reopened. The mines of Barruelo, Palencia, have increased their production from 105,904 tons in 1891 to 120,000 in 1892. As an offset, however, the Orbo mines, which are a continuation of the Barruelo properties, show a decrease, having turned out but 25,000 tons in 1892.

In Central Spain are the Belmez and Puerto Llano basins. The first is worked principally by the Compañia Hullera de Peñarroya and by the Compañia de los Ferrocarriles Andaluces. In 1892 a new concern, which is said to be connected with the Rio Tinto Company, investigated various mines belonging to the Sociedad Manchega-Bética-Vizcaina. The exploitation of the Puerto Llano basin is chiefly controlled by the Compañia de Escombreras-Bleiberg. Its production was 50,000 tons in 1891 and 60,400 tons in 1892.

The Santa Isabel mine, belonging to the Union Hullera de Puerto Llano, produces barely 10,000 tons per annum. The other important basins are those of Villanueva del Rio, in the Province of Seville, and San Juan de las Abadesas, in the Province of Gerona. Nothing worthy of mention occurred in either of them in 1892.

PRODUCTION OF BITUMINOUS COAL AND LIGNITE IN SPAIN.

Provinces.	1891. Bituminous, Tons.	1892. Bituminous, Tons.	Provinces.	1891, Tons.	1892, Tons.
Oviedo	695,279	720,000	Guipuzcoa	11,900	14,870
Cordoba	237,000	254,000	Barcelona	6,200	6,000
Palencia	139,063	148,500	Baleares	4,657	8,500
Sevilla	113,167	103,000	Lerida	5,100	5,900
Ciudad-Real	55,600	70,000	Teruel	1,085	1,140
Burgos	750	20	Santander	733	730
Total	1,290,464	1,353,860	Total	29,675	37,140

Lignite.—Nothing of interest occurred in the lignite industry during 1892. The exploitation of this mineral continues on a limited scale. The railroad that is to cross the Province of Teruel, and which will facilitate the mining of its Cretacean coals, has not advanced in 1892.

Iron-mining.—The mining of iron ore for export has been helped this year by the depreciation in silver, as the miner pays in silver and sells for gold. The increased shipments from Bilbao are due to this fact. I estimate the entire shipments for 1892 at 4,000,000 tons, a quantity exceeded only by the shipments in 1887 and 1890. The relatively short period which remains to the mining industry of Somorrostro has induced considerable new business in iron ore, not only in the north, but in the Levantine region of Spain. The latter has been carefully studied by Don Juan Pie, who has published the results of his investigation in the *Revista Minera, Metalurgica y de Ingenieria* of Madrid. In 1892 a company was organized by Bilbao capitalists to work the iron-ore deposits in the Sierra de Enmedio in the Province of Almeria. The Santa Matilde pit (*roza*), in Herrerias de Cuevas (Almeria), has been pumped dry by the Messrs. Borner of London.

This firm has also erected successful protective works against the Almazora River, so that it will be possible in 1893 to renew the mining of manganiferous iron ore, for which there is good demand.*

In the Province of Santander the Setares and Decido companies mine annually about 150,000 tons each. The Camargo Company does not mine more than 50,000 tons per annum.

PRODUCTION OF IRON ORE.

Provinces.	1891, Tons.	1892, Tons.	Provinces.	1891, Tons.	1892, Tons.
Vizcaya	3,719,660	4,339,000	Navarra	15,330	13,800
Murcia	350,000	388,000	Guipuzcoa	18,080	12,500
Santander	340,254	366,500	Other Provinces	50,000	40,000
Almeria	163,224	174,350			
Malaga	99,589	70,700	Total	4,822,080	5,465,150
Oviedo	65,943	60,300			

Iron Smelting.—Former hopes for the development of the iron industry were based upon the approval of the bill imposing duties on railway material. These hopes vanished when the sessions of the Cortes came to an end last July without any discussion of the bill. It is hoped that at the reassembling of the Cortes in December the bill will be approved, for such a law will further the manufacture of railway material, and indeed will benefit the entire iron industry. In expectation of this a company has been organized—the Sociedad Constructora Guipuzcoana—having as a working basis the old plant of Beasain.

As a new feature in 1892 I may mention the beginning of the manufacture of files in Bilbao and the construction of mail-cars in Barcelona. The Aurrera factory at Bilbao, the manager of which, Don Fernando Alonso, has been so success ful in various enterprises,—first in the making of cast-iron tubes and subsequently in cast-steel,—has commenced to manufacture files, taking advantage of the excellent quality of steel made there. An industry has thus been created which will free Spain from the necessity of importing the English article. The Sociedad Material para Ferrocarriles y Construcciones has delivered the first consignment of the 70 mail-cars with which it is obliged to supply the Spanish railroads.

Another important event of 1892 is the construction of large 10,000 horsepower engines for the Navy Department by La Maquinista Terrestre y Maritima Company of Barcelona, and Messrs. Portilla, White & Co. of Seville.

The Sociedad de Altos Hornos y Fabricas de Hierro y Acero de Bilbao continues at the head of the iron industry in Spain, but it is struggling against the difficulties offered by the limited home consumption. In 1891 this company produced 83,500 tons of pig-iron and 51,676 tons of manufactured iron and steel, against 57,390 tons of pig-iron and 32,723 tons of manufactured iron and steel in 1892. This company supplied all the iron for the large building of the Chamber of Commerce (Bolsa de Comercio) of Madrid. The following figures show the advance made by it in 1892:

Products.	1891, Tons.	1892, Tons.	Products.	1891, Tons.	1892, Tons.
Iron ore	150,498	172,264	Iron, puddled	2,260	4,315
Pig-iron	108,104	102,179	" rolled	21,258	28,864
Steel, ingot	17,305	22,640			

* In the Province of Almeria there were produced in 1891 as much as 14,682 tons of argentiferous iron ore, which are not included in the 163,224 tons inserted in the table. In 1892 no ore of this kind was obtained.

The Astilleros del Nervion Company which was organized for the construction of armed cruisers for the National Navy, suspended payment during the year and forced the Government itself to finish the vessels. It is probable that the company will reorganize when the cruisers are finished.

Among the producers of charcoal iron are the Santa Ana de Bolueta Company in Biscay, which produced 1860 tons in 1891 and 2100 tons in 1892; the firm of Viuda de Urigoitia é Hija, of Araya, in Alava, which produced 2975 tons in 1891 and 3355 tons in 1892; and the Guriezo plant of the Sociedad de Altos Hornos de Bilbao, in Santander, which produced only 357 tons in 1891 and 511 tons in 1892.

Of the Asturian works the most important is the Fabrica de Mieres. This company is also the heaviest producer of coal and iron ore in Asturias, and it is the only one which uses exclusively the silicious Devonian ore of the Province without mixture with the Bilbao product. In 1892 it produced 200,000 tons of coal, 32,000 tons iron ore, 18,500 tons pig-iron, and 13,000 tons rolled iron. It also finished in 1892 its first battery of 12 Coppée coke ovens, which will produce 7000 tons of coke per annum. During the month of December the same company blew in another blast-furnace of a daily capacity of 40 tons of pig-iron.

The Talleres de Zorrosa, founded in 1890, have a boiler-shop and a foundry. In 1891 they worked 1490 tons, of which 900 tons went into the boiler-shops. In 1892 they used 1755 tons of iron, of which 1050 tons were for boilers, armatures, etc. The Talleres de Deusto manufacture steel castings and forgings.

The tin-plate industry, inaugurated in Spain by the La Iberia Company of Bilbao, shows an increase in production during 1892; but the imports of the English article have decreased only 30% from previous years. A second plant, of greater capacity than the present works, is projected.

The manufacture of wire is established in Gijon (Oviedo), in Bilbao, and in Los Corrales (Santander). The Fabricas de Moreda y Gijon Company produced in 1892 the following quantities: Iron wire, 2 133 tons; galvanized, 165 tons; wire nails, 1352 tons. The best steel wire is made by Señor Jauregui near Bilbao.

I have not succeeded in obtaining complete returns from the iron works of Spain, but the following table shows the estimated quantities:

PRODUCTION OF IRON AND STEEL.

Provinces.	Pig-iron.		Soft Iron.		Steel.		Manufactured Iron and Steel.	
	1891.	1892.	1891.	1892.	1891.	1892.	1891.	1892.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Vizcaya	240,600	170,570	14,900	35,000	59,900	45,000	84,890	65,000
Oviedo	34,030	36,110	33,026	33,925	9,497	9,317	19,910	20,800
Guipuzcoa	....	....	4,020	4,100	480	490	....	....
Navarra	500	890	3,040	3,500	95	108	....	....
Alava	2,975	3,355	2,800	3,500	....	....	....	....
Malaga	....	....	2,134	2,156	....	....	....	....
Santander	357	511	....	....	....	....	....	....

Quicksilver.—At the Almaden mine the main shaft has been sunk to a total depth of 351 meters, of which the last 11 are for the sump; the twelfth level has been started at a depth of 340 meters, or 25 meters below the eleventh level. The mine will thus be prepared for working in 1900, when the unfortunate contract which the Spanish Government signed in 1870 with the Messrs. Rothschild of London shall have expired. Unfortunately this preparatory work must be done very slowly, since the Government must be authorized by the Cortes before it can

buy the compressed-air drills proposed by Don Eusabio Oyarzabal, directing engineer at the mines.

During the first 11 months of 1892 there were extracted from the three levels of San Pedro y San Diego, San Francisco, and San Nicolas 17,855 metric tons of ore, carrying on an average 8% quicksilver. At El Porvenir quicksilver mines at Mieres (Asturias) there were taken out from the Peña and Esperanza concessions 6059 tons of ore in 1891 and 5350 tons in 1892, the ore carrying on an average 1% of quicksilver.

The production of the Almaden furnaces, where 14,990 tons were treated in 1892, was as follows (flasks of 34.507 kilos): January, 7738; February, 7433; March, 6996; April, 6347; October, 606; November, 7262; December (estimated), 7738—total for 1892, 44,120 flasks. In 1891 the production was 48,124 flasks. This decrease of 4000 flasks in 1892 was due to the fact that the Treasury Department did not include in the budget the necessary increase of appropriation required for sinking the San Teodora shaft 11 meters below the twelfth level. This work had to be done without delay, and the expenses connected with it had to be deducted from the sum destined by the Government for the extraction and production of ore. In addition to this the quicksilver market has been somewhat weak for the past few months, and it was judged advisable to diminish the production of metal in order not to increase the stocks on hand. The Porvenir Company produced 2087 flasks in 1892, which was somewhat more than in 1891.

Lead.—Lead-mining has suffered more than any other branch of the mineral industry of Spain, owing to the course of the metal market and to the various circumstances which I have enumerated in the preceding pages. Thus in the Province of Murcia during the months of July, August, and September, 1892, the production of ore fell 6070 tons below the production for the three previous months. In the third quarter of the year only 157 mines were in operation, while in the preceding quarter 181 were working. Thus it appears that 24 mines closed down at the beginning of the fiscal year owing to the increase in the new taxes. This fact also explains why the Castuera (Badajoz) mines closed down in 1892. The mines were worked by the French firm of A. d'Eichthal, and a depth of 400 meters had been reached. M. d'Eichthal worked principally two veins in Minaflores, one for 1200 meters and the other for 800 meters on the course of the deposits. The deposit showed a column of carbonate between columns of galena, to a depth of 300 meters. The intersection of the two veins, at an angle of 12°, is remarkable for being completely barren. In La Campana an old Roman assaying furnace was found. Some lead still remained, but it was desilverized.

The San Fernando, San Guillemo, and other mines near Azuaga (Badajoz) have also stopped working; but the Triunfo mine of the same place has continued in operation. Some new enterprises have been commenced in 1892 on new lead deposits, among which may be mentioned the Sociedad Anonima Anglo-Vasca de las Minas de Cordoba, a stock company, which is exploring some argentiferous veins. It was organized by Biscayan capital, which in Spain is the most willing to engage in mining industry.

The Horcajo mines, in Ciudad Real, show a decrease of 2200 tons in 1892, compared with 1891, when 7558 tons of salable argentiferous ore were obtained. The mines of Posadas (Cordoba) continue to work their argentiferous blende and

galena, showing a production of 5500 tons of blende and 1400 tons of galena. The Mazarron mines (Murcia), which are worked by the Compañia de Aguilas, produced 28,221 tons of argentiferous lead ore in 1891. The Quinto del Hierro mines, at Almadenejos (Ciudad Real), are being explored; there is a vein which was formerly worked by the Romans, which has 25 centimeters of galena running 4483 grams of silver to the metric ton.

The lead district of Linares-La Carolina (Province of Jaen) and the districts of the Province of Almeria have been very quiet. The Linares Lead-mining Company produced 5500 tons, the Fortuna Company 4770, and the Alamillos Company 3350 tons of lead ore—making in all say 7700 tons of lead. The Peñarroya Company produced 21,800 tons and smelted 32,400 tons, which produced 18,330 tons of lead and 22,080 kilos of silver.

The problem of unwatering the famous Sierra Almagrera has been solved. After costly delays incurred in calling for plans, none of which proved successful, a conference was held in October last, when it was decided to award to Mr. Charles Arthur Friend, an English civil engineer, the work of unwatering the mines for 60 years. The following are the conditions:

First, to establish four shafts connected with one another and with the Mediterranean by means of levels; second, to install near the sea, within the period of two years, two engines, each with power to raise 7000 cubic meters of water in 24 hours; third, to give bonds in the sum of 125,000 pesetas ($25,000); fourth, to have the mines dry a year after the installation of the machinery; fifth, to sink each shaft 5 meters lower every year until a depth of 160 meters below the sea-level is reached; sixth, to collect 12% of the product of each mine. If this should not cover expenses and 6% interest on the capital, the contractor may choose between raising the royalty to 15% and throwing up the contract; in the latter case the mining companies will reimburse the expenses incurred by the contractor. Mr. Friend has until Jan. 4, 1893, to give his bond for the sum specified. If he does not give it, the contract lapses.

PRODUCTION OF LEAD ORE.

Provinces.	Argentiferous.		Non-argentiferous.	
	1891, Tons.	1892, Tons.	1891, Tons.	1892, Tons.
Jaen	....	....	114,000	104,000
Murcia	116,757	104,000	120,000	100,000
Almeria	7,200	1,100	20,500	25,000
Ciudad Real	14,558	5,339	6,700	5,000
Badajoz	670	500	16,517	16,000
Guipuzcoa	1,940	1,827	90	....
Navarra	1,058	840	....	....
Granada	....	....	1,700	1,700
Baleares	....	....	589	380
Santander	....	....	808	....
Cordoba	1,606	1,800	2,000	1,800
Totals	143,789	115,406	282,904	253,880

We have received definite information from the La Cruz Company of Linares, the Linares, the Fortuna, the Alamillos, and the Peñarroya companies, and from the Compañia Metalurgica de Mazarron. The first produced in 1891 and 1892, respectively, the following quantities: 14,000 and 15,000 tons of pig-lead, 850 and 800 tons of sheet-lead, 320 and 300 tons of shot, and 5800 and 6000 kilos of fine silver. The Mazarron Company produced 20,140 tons of argentiferous lead in 1891 and 22,250 tons in 1892.

In the Province of Almeria in 1891 there were produced 4991 tons of lead poor in silver and 12,823 tons of argentiferous lead. The corresponding figures for 1892 are, approximately, 4900 tons of the first and 15,500 tons of the latter.

The approximate production of lead in Spain during 1892 may be fixed at 160,000 tons, of which two thirds are of non-argentiferous lead and the remaining third of argentiferous.

Copper.—Copper-mining has suffered less than any other branch from the crisis now hanging over the Spanish industry, for the reasons mentioned in connection with the mining of iron ore. It is, like the latter, an export industry.

In the Province of Huelva the Bede Metal Company, of Newcastle, England, has abandoned open-air calcination at its Las Cabezas mine, employing in its stead vitriolization by weathering. In 1891 this company produced 50,472 tons of pyrites, of which 23,230 tons were exported to England, and the remainder was worked on the spot by the wet way, producing 372.5 tons of copper precipitate. In 1892 it produced 46,300 tons of pyrites, of which 21,000 tons went to England; the remainder gave 509 tons of copper precipitate, containing 80% copper.

The Aguras Teñidas Company produced 186,750 tons of pyrites in 1891 and 200,000 tons in 1892, obtaining a copper which is especially free from arsenic.

In the Province of Seville two companies are mining copper ore—one the Compañia Gaditana de Minas, and the other the English Seville Copper and Sulphur Company. They produced 20,524 tons in 1891 and 19,753 tons in 1892.

The French company of Jerez-Lanteira (Granada) produced some 4740 tons of copper ore in 1892, of which 2500 tons assayed 7% and 2240 but 2%. The Cantabrian Copper Mines Company, Limited, works the copper mines of Soto, near Reinosa (Santander). It produced 65 tons in 1891 and 203 tons in 1892, running 30% copper. The Profunda mine, near Villamanin (Leon), famous for its richness in cobalt, produced 2735 tons of copper ore in 1891. In 1892 the production has not exceeded 1900 tons. In addition to this there must be counted 36 tons of copper-cobalt ore and 1 ton of cobalt ore.

There is nothing especial to report of the metallurgy of copper. In regard to the alloys of this metal, the Metal Delta Española Company, established in Bilbao, has continued to work successfully. It supplied the national factories at Seville and Toledo with more than 60 tons of shells for rifle-cartridges, grenade-tubes, and other purposes. The San Juan de Alcaraz Company, manufacturers of brass articles, commences to show signs of new life, although it must now compete with a new factory recently established at Santander, which manufactures the same articles.

The copper production of Spain in 1891 and 1892 was as follows: In 1891, ore, 2,475,311 tons, against 2,526,694 tons in 1892; copper, 47,569 tons in 1891 and 49,600 tons in 1892.

Zinc.—In regard to the calamine and blende, the most notable feature during 1892 has been the eagerness with which workable deposits have been sought by the large zinc companies, in view of the irregularity of the deposits that they are now working. In the Province of Santander, which continues the foremost producer of these ores, the Real Compañia Asturiana produced 27,117 tons of calcined calamine in 1891 and 24,200 tons in 1892, which came from the rich mines of Reocin and Udias. In spite of the difficulties offered in the Province of Teruel by the lack of railroads, the exploitation of the calamine of the town of Linares,

situated in the very heart of the Province, is being developed. The ore carries on an average from 49% to 54% of zinc. The product of 1892 shows an average of 54%. A great future is in store for this Province when it shall have economical transportation. The total output of zinc ore amounted in 1891 to 55,817 tons, and in 1892 to 50,100 tons.

The only zinc metallurgical establishment in Spain belongs to the Real Compañia Asturiana; it is situated in Arnao, near Aviles (Asturias). In 1891 there were produced 5656 tons of zinc, of which 2820 tons were sheet-zinc. The output for 1892 amounted to 5925 tons (2880 tons of sheet). The Belgian process is used in reducing the calamine at Arnao. The output of tin ore is about 100 tons; of antimony, about 100 tons. Very small quantities of manganese, nickel, cobalt, arsenic, phosphates, asphalt, talc, and kaolin were obtained in 1892, but they are not worth further mention. Of sulphur, 27,000 tons were produced in 1892, against 30,576 tons in 1891. Salt is found in many parts of Spain, but no statistics are at present available. Hydraulic lime was produced in 1891 to the amount of 54,000 tons, and 47,500 tons in 1892, by the factories of Zumaya in Guipuzcoa, while in Gerona 9600 tons were made in 1891, and 11,000 tons in 1892.

IMPORTS INTO SPAIN.

Articles.	1891 (12 Months).		1892 (11 Months).	
	Tons.	Dollars.	Tons.	Dollars.
Coal	1,634,400	8,825,006	1,527,612	8,151,174
Coke	228,926	1,236,002	161,449	863,099
Tar, pitch, etc	36,430	728,621	24,253	485,056
Petroleum, crude	54,821	2,192,863	41,935	1,677,376
Pig Iron	34,609	484,533	27,591	386,280
Molded Iron	18,013	776,996	9,796	454,987
Iron and Steel	45,002	1,876,979	29,642	1,133,369
Tin plate	2,659	265,929	2,845	284,582
Tin in bars	625	312,867	730	364,839
Gold in bars	11,922 kg.	1,191,640	7,738 kg.	4,797,560
" coin		4,766	7,738	3,935
Silver	544,901 kg.	21,796,040	97,468 kg.	3,898,720
" coin		487,916	97,468	840,939
Alkaline carbonates	23,159	1,019,037	23,130	1,017,698
Nitrate of soda	15,816	949,007	16,373	982,175
Sulphur	7,125	185,271	8,428	219,107
Engines and boilers	8,238	1,977,295	5,993	1,528,175
Total		44,310,768		27,089,071

EXPORTS FROM SPAIN.

	1891 (12 Months).		1892 (11 Months).	
	Tons.	Dollars.	Tons.	Dollars.
Iron ore	4,369,623	9,613,170	4,322,317	8,644,633
Copper ore	661,913	5,030,537	486,082	3,694,232
Zinc ore	38,582	233,791	36,139	218,722
Lead ore	9,415	710,017	13,091	972,886
Manganese ore	3,885	36,520	9,015	84,741
Antimony ore	547	32,799	297	17,841
Salt	225,870	677,610	204,463	613,389
Coal	11,461	59,597	14,146	76,388
Iron pyrites	283,724	567,447	395,015	790,111
Phosphates	1,935	3,870	1,740	3,480
Pig-iron	66,657	1,066,514	41,358	662,132
Precipitated copper	32,126	4,818,917	33,239	4,297,131
Copper matte	24,488	284,055	27,983	324,598
Zinc	2,047	212,931	1,877	155,238
Lead	148,026	13,260,147	134,999	11,305,775
Mercury	1,885,856 kg.	2,187,593	1,632,002 kg.	1,827,842
Gold, bullion and coin	63 kg.	39,060	138.8 kg.	86,056
Silver, " " "	91,292 kg.	3,651,664	192,211.3 kg.	7,688,452
Total		42,486,239		41,503,647

The Mineral Resources of Cuba.

By Eduardo J. Chibas, C.E.

Manganese.—The Cuban manganese deposits are found in the Province of Santiago de Cuba, either at the summit or on the flanks of the ranges that branch off from the Sierra Maestra.

The ores are chiefly highly crystalline pyrolusite and psilomelane. Wad is also found in considerable quantities at some of the mines. These ores generally occur with red or yellow jasper, dipping at steep angles; sometimes they are completely embedded in this rock, and occasionally they occur as pockets in clays of various colors.

In the latter case it sometimes happens that several hundred tons of excellent ore are found in one body, but for the most part the ores occur as lumps of various sizes, more or less mixed with clay and fragments of jasper. The large lumps can be hand-sorted, but the small ones can be saved only by washing. In some of the mines the amount of "waste-ore" appears to warrant the erection of a plant to reclaim it, but the mine-owners do not as yet appreciate the importance of this system. Manganese ore mining began in Cuba in 1887, and the production for that year was 40 tons.

In 1888 there were exported 1581 tons, and this amount was increased during the fiscal year 1889–90 to 2240 tons. Prices in the United States were then very remunerative, and so much interest was aroused that over 100 deposits are said to have been discovered. Many of these were opened and worked, and during the fiscal year ending June 20, 1891, shipments from the port of Santiago de Cuba rose to 25,799 tons, valued at $345,135, or $13.38 per ton. As the ore had to be carried on the backs of mules for distances varying from 1 to 15 miles, the cost of transportation was very high. This, in connection with a decline in the market, caused many of the mines to close. During the fiscal year ending June 30, 1892, only a few thousand tons were shipped.

The Carnegie Steel Company of Pittsburg has taken most of the Cuban manganese ore, and the average composition has been: Metallic manganese, 45 to 53; silica, 4 to 9; phosphorus, 0.03 to 0.10. One cargo from the Gloria mine gave 55.21% metallic manganese.

Many of the mines are found on the line of the Sabanilla and Maroto Railway, the most extensive being those of the Pompo group, about 12 miles from Cristo station. Mining at this place is very easy: after removing the soil, a man with pick and shovel can put out from three to four tons per day. This is packed in bags of 100 lbs. capacity, and carried by mules or in carts to Cristo, and thence by rail to Santiago de Cuba. The cost, in round numbers, of placing a ton of ore in Philadelphia is as follows: Mining, $1.50; bagging, $1.50; transportation to railway, $5; handling at Cristo and freight, $1.50; handling at Santiago, $0.50; freight to Philadelphia, discharge, insurance, and commission, $4—total, $14, which is equivalent to $12.60 in United States currency. A Pennsylvania company has recently been organized to develop these mines and a railroad from Cristo (12 miles) has been located and is now under construction.

The Isabelita, Margarita, and Boston mines form another group that has con-

tributed a large part of the manganese ore shipped from Cuba. They are about 2½ miles from Cristo, and transportation over this distance costs $1.50 per ton. The mining is usually done by contract at $3 to $4 per ton.

Copper.—About 75 years ago several English companies were organized to work the rich copper deposits in the vicinity of Santiago de Cuba. The enterprise was successful up to 1868. At present the workings are filled with water, which is pumped out and the copper in solution recovered by precipitation. Very little of this is done, however, and that by private persons. The discovery of the contiguous manganese deposits has revived interest in these mines, and there is talk of repairing the 12 miles of gravity road built to Santiago.

Asphaltum.—I have not been able to ascertain the total amount of asphaltum produced in Cuba, and can only say that during the fiscal year ending June 30, 1892, 4510 tons were exported to the United States. As to the mineral wealth of the Province of Santiago de Cuba, it may be said that in the Government office the following claims have been filed: Manganese, 861; copper, 216; petroleum, 6; coal, 29; gold, 9; silver, 3; lead, 5; iron, 1017. The superficial area covered is about 1,000,000 acres, but the actual developments are at present inconsiderable except in regard to iron ores, of which I now give a brief account.

Iron.—The Cuban iron-ore deposits, one of the most important groups of Bessemer-iron mines in the world, are found in the range of mountains called the Sierra Maestra, which skirts the southern coast of the Province of Santiago de Cuba. The ore can be mined with great facility by means of side-hill cuts. The average analyses of the cargoes have been between 58% and 65% of metallic iron and about 0.02% of phosphorus. Though this mineral had long been known to exist in Cuba, it was not until 1880 that operations were begun, and that year many applications were filed in the Government offices for titles of ownership. Soon afterward negotiations were closed with a syndicate of Pennsylvania capitalists for the sale of the Juraguá group of mines, and concessions were obtained from the Government to build a narrow-gauge railroad from the mines to the port of Santiago de Cuba, a distance of 17 miles. The railroad was to be exempt from taxation for 99 years, and all the material required for its construction and maintenance was to be admitted free of duty. The line was laid through a very mountainous country, and the first car-load of ore was shipped late in 1884. Since then the output has been increasing year by year, and in 1891 it amounted to 330,000 tons. To haul the ore from the mines to the port there are at present in use about 20 locomotives and over 2000 cars, while the total number of men employed averages about 1500. The company has built an iron pier at the harbor of Santiago de Cuba high enough to allow the railroad cars to dump directly into the steamers. There are no ore docks, so the company must have sufficient cars to allow the loaded ones to be side-tracked until the arrival of the steamers, every two or three days. The company controls a regular line of iron steamers plying between their pier at Santiago de Cuba and Philadelphia or Baltimore. Most of the ore is consumed by the Pennsylvania Steel Company and the Bethlehem Iron Company. It is estimated that over $3,000,000 has been spent in this enterprise, with gratifying financial results.

In 1890 the Sigua Iron Company, composed of Philadelphia capitalists, was organized, and purchased another group of mines in the same mountain range,

about 30 miles from Santiago de Cuba. It has constructed eight miles of standard-gauge railroad. An ore dock of 5000-ton capacity was built in the open sea, and will be protected from the prevailing southeast winds by a breakwater now in process of construction. The first shipment of ore from this group of mines arrived in Philadelphia a few weeks ago in the American whaleback steamship "Joseph L. Colby." A portion of the cargo went to the Midvale Steel Company, whose analysis gave: Metallic iron, 67.576%; phosphorus, 0.014%; sulphur, 0.026%; silica, 1.400%.

The Spanish-American Iron Company, with Western capital, chiefly from Cleveland, Ohio, is a concern that is developing a group of iron mines situated between Sigua and Juraguá. The mines are four miles inland. The railroad and ore-docks will soon be completed and shipments begun. Other mines in the vicinity have not yet been developed.

The amount of iron ore imported into the United States from the Juraguá group of mines, according to the figures furnished by the Bureau of Statistics at Washington, D. C., is as follows:

IMPORTS OF IRON ORE INTO THE UNITED STATES FROM THE JURAGUA MINES.

For fiscal years ending June 30.

1885....28,209 tons.	1887....109,928 tons.	1889....225,525 tons.	1891....326,043 tons.
1886....51,268 "	1888....117,504 "	1890 ...287,322 "	1892....265,993 "

Total amount to June 30, 1892........... 1,541,655 tons.

These figures also fairly represent the Cuban production of Bessemer-iron ore, as most of it has come to this country.

SWEDEN.

By Hjalmar Lundholm.

In Sweden granites, gneisses, and some other rocks of the Archæan series predominate, and only in comparatively small districts are these covered by Palæozoic and Mesozoic strata. Despite this apparent uniformity, the country is rich in mineral resources, as many of the Archæan rocks are valuable for building and decoration, and many inclose large deposits of useful minerals.

The stone industry has, particularly during the last 15 or 20 years, risen to great importance. By the official geological survey and by private investigations it is known that Sweden has an ample supply of the most beautiful varieties of granite, porphyries, and other siliceous rocks, and many of them are easily worked, and occur along the sea-coast where there are transportation facilities. The demand for durable building stone is rapidly increasing. Many companies have been formed to develop the industry, but some of them are hampered by want of capital. The great market for Swedish granite is Germany, but large quantities are also sent to Denmark, and of late years even to Scotland, whence some is sent to America. Some of the granite firms employ from 200 to 300 workmen, and one firm not fewer than 1000. Reliable figures for the whole industry cannot at present be obtained. Besides granite, Silurian limestone is worked on a large scale, but mostly for home consumption.

Of the different ores occurring in Sweden, those of iron are, beyond comparison, the most important. Some deposits of these ores have been mined on a comparatively large scale for several hundred years; some, of enormous extent, have not yet been touched. As regards geological relations, the principal Swedish iron ores have much in common with the American deposits of Archæan or pre-Cambrian age. The richest and purest occur generally as lenticular-shaped beds in crystalline limestone, and in granite, mica schists, and similar rocks, which are supposed to belong to the most recent part of the Archæan series. Some of the more important ores occur in gneissic rocks. Besides these, great ore masses are found in hyperite, and finally bog-ores are found in the Province of Smaland. The principal Swedish iron ore is magnetite, but hematite also occurs in large quantities; sometimes both kinds are even intimately mixed.

The Swedish iron ores are, as is well known, extraordinarily free from phosphorus. Those of Dannemora contain only 0.003%, those of Persberg from 0.004%

to 0.005%, and those of Stora Bispberg less than 0.01% of phosphorus. In the ores of the middle and southern parts of the country the percentage of phosphorus generally varies between 0.01 and 0.05, but in Grãngesberg, in the same district and in Gellivare, Kirunavara, and other places in Lapland, there are ores containing as much as from 4% to 6% or even more.

In Sweden seven large ore districts can be distinguished. 1. Lapland, in the northern part of the country. 2. The Province of Jemtland. 3. The Provinces of Vermland, Nerike, Vestmanland, Dalecarlia, and Gestrikland. 4. The Province of Upland, near the Baltic Sea. 5. The southern part of the Province of Sodermannland. 6. The southern part of the Province of Nerike and the northern part of Ostergötland. 7. The Provinces of Ostergötland and Smaland, in the southern part of the country.

The first of these districts contains the largest iron-ore deposits and also copper and lead ores. On account of lack of transportation, these deposits, 70 to 120 miles from the sea-coast, have not been worked to any extent until this year, when the railway to Gellinore was completed by the Government, and a new company, Aktiebolaget Gellinore Malmfatt, started mining. The ore is generally very free from sulphur, and contains from 45% to 70% of iron and from 0.025% to 4% or 5% of phosphorus. During the year 1892 about 135,000 tons were exported.

The ores of Jemtland, in the second district, are principally copper-pyrites and some iron; none are worked at present.

The third district is the most important, as it contains a great number of mines now being actively worked. The ores are iron, copper, lead, zinc, manganese, and gold. In the whole district 869,385 tons of iron ore were mined in 1891, of which Grãngesberg, Norberg, Striberg, and Persberg produced the greater part. Copper ore is mined at Falun and Kafveltorp; the production in 1891 was 329 tons of refined copper. Lead ore, generally argentiferous, is mined chiefly at Kafveltorp, Hellefors, and Sala; zinc ore at Langfall; manganese ore principally in Langban. Gold occurs in quartz, embedded in pyrite, in the copper mine of Falun; in 1891 107.2 kilograms of gold were obtained.

Dannemora is the most important mine of the fourth district. The iron ore here, which is known to be exceptionally pure, occupies a horizontal area of 9000 sq. ft. In 1891 the production was 59,646 tons, and for the whole district 89,310 tons.

The production of iron ore in the fifth district was in 1891 about 20,000 tons, principally mined at Kantorp.

In the sixth district occur large quantities of zincblende and some galena at Ammeberg. Of the first-mentioned ore 42,314 tons were produced and exported in 1891.

The copper-ore deposits at Atuidaberg are the most important in the seventh district. In 1891 175 tons were extracted from 6440 tons of ore.

Ore deposits occur in several places outside of the districts above described. Among these may be mentioned the galena deposits of Nasa-Fjell, in Lapland; the manganese mines at Bölet, in Vestergötland, and at Speleryd, in Smaland; and the gold-bearing quartz at Adelfors, in Smaland.

The following table is taken from the official statistics published by the Swedish Government:

SWEDEN.

Years.	IMPORTED.								
	Coal and Coke.		Iron and Steel, Unwrought and Partly Unwrought.		Iron Manufactures.	Machinery.	Mineral Oil.	
	Tons.	Dollars.	Tons.	Dollars.	Dollars.	Dollars.	Tons.	Dollars.
1879	860,696	2,663,820	....	743,310	982,260	1,060,830	13,564	642,870
1880	1,141,214	4,121,010	....	1,040,040	882,900	1,414,260	12,415	657,180
1881	1,080,688	3,501,360	....	1,186,920	1,049,760	1,911,330	16,891	912,060
1882	1,230,321	4,293,810	....	950,130	1,533,330	2,138,940	17,862	936,360
1883	1,249,264	4,384,800	....	1,153,710	2,485,620	2,535,570	19,091	1,022,220
1884	1,377,725	4,394,520	42,065	969,300	2,331,990	2,670,840	23,617	1,261,160
1885	1,491,574	4,567,590	42,565	1,454,220	2,441,070	2,678,400	24,698	1,318,950
1886	1,456,570	4,274,100	43,437	1,065,420	2,378,160	2,258,280	27,801	1,408,590
1887	1,480,433	4,350,780	36,269	661,500	2,347,920	1,967,760	27,641	1,037,340
1888	1,682,949	5,597,910	45,732	1,525,230	2,593,890	2,528,280	26,015	1,112,130
1889	1,955,971	7,558,380	33,692	1,093,770	2,476,440	3,335,040	45,287	2,181,330

Years.	EXPORTED.										
	Glass and Glass-wares.		Pig-iron.		Iron Manufactures.		Machinery.	Steel.		Zincblende.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1879	2,451	195,750	34,569	526,985	166,399	6,650,738	316,440	8,549	1,086,037	20,696	262,911
1880	2,966	247,320	61,585	1,075,680	194,178	9,533,430	684,180	8,155	517,860	18,166	230,850
1881	2,677	247,590	5[illegible].469	898,560	203,257	8,801,190	745,740	7,170	1,239,030	15,422	208,170
1882	3,1[illegible]	242,190	5[illegible]32	1,053,270	223,203	10,544,580	697,410	9,784	607,500	22,459	303,210
1883	4,0[illegible]	303,210	52,313	988,740	210,988	10,494,630	703,620	10,887	676,080	25,940	35[illegible],190
1884	3,958	2[illegible]5,650	54,426	1,028,700	213,449	9,971,100	651,780	9,820	1,325,700	18,940	25[illegible],690
1885	4,124	325,880	47,527	866,160	203,097	8,897,580	550,800	......	....	[illegible]3,055	378,740
1886	2,685	244,350	58,139	941,760	195,772	8,068,950	741,150	......	....	25,280	341,280
1887	4,006	352,620	49,285	718,470	225,876	8,788,230	625,860	......	....	26,423	356,670
1888	4,041	442,580	49,099	702,540	228,912	8,235,540	730,620	......	....	25,322	341,820
1889	4,907	431,460	79,378	1,223,640	245,979	10,255,950	707,940	......	....	24,018	324,270

Mineral Products.	1887. Metric Tons.	1888. Metric Tons.	1889. Metric Tons.	1890. Metric Tons.	1891. Metric Tons.	1892. Metric Tons.
Iron ore	903,186	959,540	985,904	941,240	987,405	....
Pig-iron	456,625	457,051	420,665	456,102	490,913	*a*460,000
Blooms	....	238,131	226,071	225,632	224,651	*a*219,000
Bar-iron	255,383	253,090	274,734	281,833	280,430	*a*84,000
Bessemer steel	68,199	68,626	80,324	94,247	92,985	*a*75,000
Siemens-Martin steel	41,898	44,712	55,487	72,984	78,197	....
Steel of other kinds	1,468	1,205	2,010	2,055	1,592	....
Manufactures of iron and steel	49,250	59,680	74,066	78,998	72,438	....
Gold ore	1,404	930	980	1,458	2,680	....
Silver and lead ore	15,616	11,680	16,576	14,985	15,044	....
Gold .... kilos.	83	76	74	88	110	....
Silver .... "	5,834	4,648	4,293	4,554	5,748	....
Copper ore	20,653	19,170	19,952	20,670	21,883	....
Copper	919	1,053	845	831	664	....
Nickel ore	85	969	289	616	483	....
Nickel matte, etc.	....	....	411	163	12	....
Brass	271	233	333	282	301	....
Hammered copper	259	279	366	363	308	....
Lead	282	328	254	310	299	....
Litharge	....	....	....	42	21	....
Zinc ore	46,241	49,972	59,381	61,843	61,591	....
Cobalt ore	231	143	266	144	244	....
Oxides of cobalt	4	3	6	7	6	....
Manganese ore	8,659	9,690	8,645	10,698	9,079	....
Powdered pyrolusite	121	188	231	45	192	....
Iron pyrites	2,506	1,333	158	1,135	1,659	....
Sulphur	54	65	21	42	23	....
Sulphuric acid	....	1,725	1,934	2,124	2,184	....
Copper sulphate	158	197	507	636	612	....
Copperas	387	513	516	500	419	....
Red ocher	1,380	1,237	1,550	1,534	1,468	....
Alum	152	655	705	981	542	....
Cerite	39	28	....	....	....	....
Allanite	....	....	....	20	14	....
Plumbago	26	20	16	14	17	....
Marble .... value in dollars	245	125	155	133	119	....
Coal .... hectoliter	2,112,708	2,112,570	2,333,982	2,343,895	2,475,412	....
Fire-clay .... "	....	561,096	750,744	978,355	1,045,541	....

(*a*) Estimated.

Fossil coal, of the Jurassic system, occurs alternating with beds of fire-clay in Scania, the southernmost of the Swedish Provinces. During 1891 there were mined 2,475,412 tons of coal and 1,045,541 hectoliters of fire-clay. The production and export of fire-bricks, drain-pipes, tiles, terra-cotta, etc., has increased rapidly during the last years.

The production of pig-iron is largest in the Provinces of Dalecarlia and Nerike, where 262,551 tons were made in 1891, in 78 furnaces. In the whole of Sweden the production was 490,913 tons, and the number of furnaces 155. The two Provinces mentioned take the first place with regard to the further manufacturing of pig-iron.

During the year 1891 there were in operation 94 works for the production of blooms, 15 for Bessemer ingots, 22 for Siemens-Martin ingots, and 145 for manufactures of iron and steel. Gold was produced in 3 works, silver in 4, lead in 2, copper in 4. During the year 6223 men were employed in the iron mines, 23,753 in ironworks, and 5364 in the other mines and works—a total of 35,340.

The Stora Kopparberget is the oldest mine of which we have any official figures. The table shows the production for each year since 1633.

ANNUAL COPPER PRODUCTION OF THE STORA KOPPARBERGET.

Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.
1633	1,336	1659	2,224	1685	2,049	1711	1,330	1737	812	1763	798	1789	1,046	1815	874	1841	557	1867	584
1634	1,868	1660	2,393	1686	2,140	1712	1,379	1738	822	1764	619	1790	1,142	1816	631	1842	588	1868	712
1635	1,929	1661	2,222	1687	1,791	1713	1,277	1739	855	1765	782	1791	1,191	1817	595	1843	570	1869	728
1636	1,592	1662	2,595	1688	1,672	1714	1,276	1740	894	1766	732	1792	1,023	1818	692	1844	571	1870	755
1637	1,700	1663	2,532	1689	1,926	1715	1,255	1741	985	1767	846	1793	840	1819	801	1845	565	1871	701
1638	1,653	1664	2,543	1690	1,943	1716	1,161	1742	1,053	1768	555	1794	791	1820	830	1846	727	1872	711
1639	1.874	1665	2,311	1691	1,605	1717	1,093	1743	971	1769	822	1795	768	1821	766	1847	713	1873	588
1640	1,927	1666	1,992	1692	1,683	1718	1,049	1744	899	1770	754	1796	632	1822	635	1848	815	1874	419
1641	1.409	1667	1.841	1693	1,658	1719	1,079	1745	822	1771	765	1797	597	1823	642	1849	836	1875	491
1642	2,252	1668	1,845	1694	1,505	1720	1,107	1746	834	1772	791	1798	637	1824	675	1850	843	1876	581
1643	2,054	1669	2,181	1695	1,486	1721	1,079	1747	820	1773	893	1799	657	1825	546	1851	867	1877	401
1644	2,139	1670	1,849	1696	1,566	1722	890	1748	911	1774	728	1800	587	1826	541	1852	874	1878	746
1645	2,060	1671	1,812	1697	1,453	1723	1,002	1749	891	1775	856	1801	701	1827	597	1853	782	1879	598
1646	2,055	1672	1,917	1698	1,208	1724	968	1750	782	1776	659	1802	859	1828	545	1854	836	1880	669
1647	2,062	1673	2,225	1699	1,156	1725	908	1751	741	1777	868	1803	706	1829	551	1855	786	1881	626
1648	2,087	1674	2.001	1700	1,275	1726	938	1752	844	1778	860	1804	709	1830	504	1856	762	1882	534
1649	2,345	1675	2,518	1701	1,394	1727	973	1753	930	1779	865	1805	698	1831	496	1857	681	1883	532
1650	3,455	1676	2,727	1702	1,475	1728	1,010	1754	932	1780	999	1806	638	1832	503	1858	612	1884	459
1651	2,938	1677	1.991	1703	1.405	1729	981	1755	934	1781	1.031	1807	740	1833	379	1859	558	1885	443
1652	2,623	1678	2,269	1704	1,458	1730	832	1756	877	1782	1,064	1808	792	1834	451	1860	535	1886	434
1653	2,644	1679	2,541	1705	1,485	1731	900	1757	890	1783	1,071	1809	798	1835	538	1861	472	1887	418
1654	2,099	1680	2,226	1706	1.484	1732	889	1758	1,026	1784	1,048	1810	685	1836	544	1862	536	1888	411
1655	2,082	1681	1,915	1707	1,506	1733	840	1759	942	1785	1,140	1811	580	1837	597	1863	627	1889	356
1656	2,106	1682	2,586	1708	1,507	1734	874	1760	731	1786	962	1812	584	1838	554	1864	575	1890	331
1657	2,151	1683	2,460	1709	1,459	1735	880	1761	637	1787	1,217	1813	660	1839	537	1865	659	1891	271
1658	2,073	1684	1,890	1710	1,391	1736	792	1762	709	1788	1,146	1814	668	1840	538	1866	626	1892	....

As early as 1228 Stora Kopparberget yielded large profits to its owners. In 1650 no less than 3450 tons of copper were produced, an amount sufficient to supply all the then civilized world. Gustavus Adolphus used to call it his "treasure," which, considering the big income the Government derived from the mine, was a most appropriate name. For many years the mine was worked by the Government, and then by the Stora Kopparbergs Bergslags Company, which now owns it. In the 700 years during which it has been worked it has produced no less than 1,200 000 tons, which, at an average price of $140 per ton, amounts to $168,000,000.

Besides this mine, the Stora Kopparbergs Bergslags Company owns other large mining properties. In 1873 it built new at works Domnarfoet, 20 kilometers from Falum, where a water power of 4000 horse-power drives all the machinery by means of 15 turbines. These works, the largest of their kind in Northern Europe, are connected by rail with Stockholm, Gottenburg, Gefle, and other ports. The production for 1891 was:

	Tons.		Tons.		Tons.
Iron ore	80,000	Sulphuric acid	2,000	Siemens-Martin ingots	26.000
Copper ore	15,000	Gold .kilos	70	Lancashire balls	7,000
Iron pyrites	500	Silver "	330	Rolled iron and steel	45,000
Copper vitriol	600	Copper ingots	500	Forged steel, etc	600
Iron vitriol	250	Pig-iron	52,000	Forged bar-iron	1,200
Red ocher	1,000	Bessemer ingots	25,000	Horseshoe-nails	600

THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

In the following paper, prepared by an eminent English statistician, the mineral products of the whole kingdom are united. These statistics may be segregated as follows: In 1890 the total value of minerals produced in the United Kingdom amounted to £92,794,481, of which England contributed £66,621,842, or 71.79% ; Wales, £14,959,188, or 16.12% ; Scotland, £10,705,780, or 11.54% ; Ireland, £406,512, or 0.44% ; and the Isle of Man, £101,159, or 0.11%. This proportion was but slightly altered in 1891, when out of a total value of £91,238,032 England's share was £65,334,539, or 71.61% ; Wales's, £15,064,012, or 16.51%; Scotland's, £10,356,054, or 11.35%; Ireland's, £394,233, or 0.43%; and the Isle of Man's, £89,194, or 0.10%.

The small share contributed by Ireland in the total is due to the absence of valuable coal fields in that island. Thus, while in England coal amounted in value to 80.48% and in Wales to 88.44% and in Scotland to 78.65% of their respective products, it was only 11.29% of the value of the Irish mineral output. Wales, in addition to coal, raises important quantities of slate and stone, which in 1891 were valued respectively at £945,204 and £540,000. Scotland, besides coal, works important deposits of oil shale and stone, which in 1891 turned out products valued respectively at £8,143,761 and £1,040,769. In Ireland salt and bauxite are the most important minerals now worked ; but on the west coast there are copper mines which are said to be workable at a profit.

The accompanying tables show that, while thirty years ago the United Kingdom was an important producer of copper, the output of that metal has steadily decreased, until it is now quite insignificant. The output of lead has also declined in recent years to about one half what it was twenty years ago. The production of tin has varied but little in thirty years, while that of zinc increased quite rapidly from 1870 to 1882, when it reached a maximum, and has since declined. Silver produced from lead has remained at quite insignificant figures. In coal and iron the production of the United Kingdom has grown enormously; it is far greater than that of any other country, amounting in fact to 35% of the whole world's output. The production per head of population has grown from about 2.40 tons per year to about 4½ tons, or an amount more than double that in the United States. With these two exceptions, it would appear, from a study of these statistics, that the United Kingdom is not likely to be as important a factor as a mineral producer as she has been in the past ; but her great manufacturing advantages will still maintain her controlling position as a market for many of the metals.

The Mineral and Metallurgical Industries of the United Kingdom.

(The tons used are tons of 2240 lbs.)

The course of business in the mining and metallurgical industries of the United Kingdom in the year 1892 has been in many ways unsatisfactory. There have been several strikes of unusual magnitude, prices have fallen all around, production has been intermittent, and consumption has shown a marked tendency to further shrinkage. The exports of iron and steel have shown for the first eleven months of 1892 a decrease in value as compared with the corresponding period of 1891.

A falling off in the production of the minerals of the United Kingdom is, however, no new thing. On the contrary, there has been an almost persistent decline, alike of quantities and of values, for the last 20 or 30 years, except in a few notable cases, including, of course, iron ores (up to 1880), coal, clays, and oil shale. The tendency of prices has been almost steadily downward over the whole period, although one or two minerals, such as coal, exhibit a greatly improved value in 1890. So far as lead-mining is concerned, the business may be regarded as unimportant. The same remark applies to copper, while tin ores are now imported into Great Britain from the Straits settlements and elsewhere in larger quantities than they are produced.*

Coal.—The production of coal for 1892 is not yet available. It must almost of necessity happen, however, that the output will be less in the year 1892 than in either of the two previous years (when it was about 185,000,000 tons): first, because of the diminished demand in iron, chemical, engineering, shipbuilding, and other prominent industries; and, secondly, because work in the principal mining districts has been greatly curtailed. The most serious suspension of work in 1892 was that which took place in the Durham coal-field, a district which in the previous year had produced 29,807,000 tons of coal—a larger quantity than was produced in any other district in the country except Wales.

In 1892, for the first time in the history of the trade, Wales took the lead of the Durham section of the great northern coal-field, although only by about 80,000 tons. In 1880 the great northern coal-field, including Northumberland, was about 14,000,000 tons ahead of South Wales.

The strike of the Durham miners commenced in March, in consequence of a proposal made by the employers to reduce the wages by about 10%. In the previous 18 months the wages of the miners in the coal-field had been raised by instalment after instalment, until at the beginning of 1892 they were some 30% higher than they had been a few years previously. This movement, of course, fell coincident with a large advance in the price of coal, which, as between 1888 and 1891, had advanced on an average by something like three shillings per ton all around. This advance of price, no doubt, enabled the coal-owners to secure very good profits during at least a part of the time that it lasted, but the ultimate effect has been very far from satisfactory. The cost of production has been increased generally—not alone in the matter of wages, but in reference to stores, standing

* For production of pig-iron and steel in Great Britain from 1865 to 1892 see table of world's production.

charges, rating, or taxation, and all the elements that enter into production. The price of coal has practically receded to its old level, while the cost of production remains higher than that level; so that the position of the coal-owners to-day is far from being as good as it was four years ago, bad as it was then. Nor has the situation been at all improved by the limitation of supply consequent upon the Durham strike.

A number of engineering and other firms that were anxious to go on with their contracts secured supplies to some extent from Yorkshire and other coal-fields; but the great majority of the consumers—those who are engaged in the iron and steel industries of the West Coast and Cleveland, as well as in Lincolnshire and one or two other districts that draw their supplies of coal and coke from Durham—simply closed their works until the strike was at an end. Then, again, the so-called strike week, which was intended to bring the demand for coal up to the level of the supply, was an utter failure. It is true that all the collieries in the country were not closed during this period, but more than half of them were; and as the weekly production of coal in the United Kingdom in 1891 averaged about 3,500,000 tons, the quantity withdrawn from consumption during this week must have been nearly 2,000,000 tons, and probably even more. So far as the Durham strike was concerned, it lasted for about three months; and as the monthly production of coal in Durham is about 2,500,000 tons, the total quantity withdrawn from consumption during the strike was about 7,500,000 tons—being, in fact, just one fourth of the annual output of the county.

The great Durham strike—the most serious and extensive, from every point of view, that has ever occurred in England—does not appear to have settled anything or satisfied anybody. For a number of years the rate of wages in the Durham district was settled by reference to the net average selling prices, which were collected for that purpose by an eminent firm of accountants and reported periodically to the employers' association on the one hand and to the men's unions on the other. The wages then fell automatically according to the amount of the fall in selling price, or *vice versa*. Previous to the adoption of this system the wages to be paid were settled by arbitration, which was usually based upon the selling price of coal, the rates of wages paid to kindred labor in the same or proximate districts, and other similar considerations. The workmen, however, appear to have become dissatisfied with both systems, believing that neither gave them their proper share of the rise of price when prices had an upward tendency. The employers, on the other hand, were not quite satisfied with an arrangement that laid them under obligation to find a definite minimum rate of wages for their workmen in bad times, whether profit was earned or not, and yet permitted the workmen to share with them to a large, if not to the fullest, extent the benefit of a rise of price as soon as it took place.

The miners were asked to submit the claim of the employers to arbitration, but they refused. One curious feature of the dispute was that prices took a further downward movement, which caused the employers to demand a further three per cent reduction. This demand was perfectly reasonable so far as the ascertainment of the selling price and the former relation of wages to prices were concerned; but it did not facilitate a better understanding, and it brought the end of the struggle no nearer. The men ultimately expressed their readiness to consent to a 10% reduc-

tion and to submit to arbitration the question of what further reduction of wages, if any, should be required. This offer was finally made the basis of a settlement, and work was resumed throughout the county generally. But the relations of producers and consumers had become so much disturbed that it was necessarily some time before most of the pits got into their old swing, and some of the older and least profitable ones having been drowned out, work has not been resumed, nor is it likely to be under existing conditions.

Iron Ores.—Any one who considered the production and importation of iron ores for the United Kingdom would be likely to suppose that so large importations of foreign ores indicated the shortening of the home supplies. Such, however, would be a very erroneous conception. There is a practically unlimited supply of lias or oolitic ores available in Cleveland, Lincolnshire, Northamptonshire, Leicestershire, and North Staffordshire, and these ores constitute about three fourths of the total home supply. But of late years they have fallen off in the quantity produced, mainly because of the increased demand for hematite iron, suited to the acid processes. Such iron could only be produced, so far as concerns domestic ores, from the deposits of West Cumberland and Northwest Lancashire; and in both of these districts the supplies are uncertain, irregular, and by many believed to be incapable of further development. At any rate, the output of these districts has been almost stationary for a number of years, at about 2,500,000 tons a year, which is only equal to the production of about half that quantity of pig. The remainder required for the Bessemer pig manufacture has had to be imported.

The relation of the increased importation of foreign ores to the total quantity of home ores consumed has been an evident feature of the iron trade of late. During the year 1891 this movement received a check, and the imports of ore fell off to a larger extent than for a considerable time previous, but in 1892 they have shown an increase of about 400,000 tons up to the end of October. No doubt this increase is partly, if not mainly, due to the reduced production of iron in the Cleveland district, owing to the Durham coal-miners' strike, and the consequently enlarged demand for hematite pig produced in other districts. About 20% of the total make of pig-iron in the United Kingdom is now and has for some years past been produced from imported ore, a large part of which is delivered to the furnaces at 11s. per ton, the average content of iron being 50%.

Pig-iron.—The production of pig-iron in Great Britain in the first half of 1892 did not exceed 2,790,918 tons, being a reduction of 921,469 tons on the make of the corresponding half of the previous year. Of this decrease 719,244 tons were in the Cleveland district, 119,304 in West Cumberland, and 107,776 in Lancashire—the three districts principally affected by the Durham strike in the first half of the year. This means, of course, a loss of something like £2,000,000, caused by the strike, to the pig-iron industry alone.

During the second half of the year 1892 the ironworks have been kept pretty steadily at work, and things have improved all round. In the Cleveland district the make of pig-iron for September reached 216,848 tons, and for October the output was 215,000 tons more. The total number of furnaces at work in this district at the end of October was 94. The output of pig in the latter half of

1892, notwithstanding the improvement in Cleveland and in Cumberland, is still likely to be considerably behind the figures for the latter half of 1891.

Only in one or two cases are any additions being made to the plant available for the production of pig-iron. Indeed, the capacity of the English works for pig-iron production has been stationary for a few years past.

The stocks of pig-iron in Great Britain have been very largely reduced during 1892. In the Cleveland district, which is the largest producer, the total stock in warrant stores was reduced in the first ten months of the year from 154,735 tons to 13,811 tons, while makers' stocks fell from 107,331 to 55,972 tons in the same period. In Scotland, again, there has been a decline of the stocks in warrant stores from 500,957 tons to 358,814 tons. No details are given of the Scotch stocks in the hands of makers, but they are understood to be very low, and may not exceed 50,000 tons. It would appear, indeed, as if the stocks in the three principal districts—the West Coast, Scotland, and Cleveland—had fallen during the first ten months of the year from 1,073,000 tons to about 506,000 tons, or more than 500,000 tons in all. The stocks at present on hand are therefore remarkably low.

Of the 2,790,918 tons of pig-iron produced in Great Britain during the first six months of 1892, the following were the proportions of different descriptions:

	Tons.
Forge and foundry	1,466,067
Hematite	1,126,178
Spiegeleisen and ferro	73,456
Basic iron	125,217
Total	2,790,918

It thus appears that forge and foundry iron constitute the bulk of the production, and that hematite iron comes in as a secondary variety. Of late years, however, the tendency has been to increase the production of hematite iron, even in districts that have adequate and excellent supplies of ore. This movement has for a long time been going on in South Wales, where the local ores are not now used to any extent, but of late it has been developed to a large extent in the Cleveland district, where the ores are abundant and cheap.

Bessemer Steel.—The make of Bessemer steel has been declining in the United Kingdom for several years past, chiefly on account of the largely reduced demand for rails. The year 1891 showed a reduced make, as compared with 1890, of over 372,000 tons of ingots and 356,930 tons of rails. The first half of 1892 showed a decrease of 273,189 tons of ingots and 210,739 tons of rails. The production of Bessemer rails during the first half of the year 1892 was only 211,884 tons, and as half of this quantity was exported, it follows that there must have been a very limited demand on the part of the home railways. The fact is that the railway companies have been limiting their purchases of all materials as much as possible, in view of the possibility of having their revenue reduced by the operation of the new schedule of maximum rates which goes into operation on the first of January, 1893, and in view also of the depressed condition of trade. Usually the home companies have consumed about one third of the total British make of steel rails. Consumption and exports alike have fallen off for the time being, so that

the condition of the English rail trade is very precarious indeed. Much of the falling away in rails might be made good by the use of Bessemer steel for other purposes had not the open-hearth steel industry been already so well developed; but now shipbuilders, tin-plate makers, and other large users have got into the habit of using open-hearth steel, and appear to prefer it.

During the year 1892 there were 82 acid and 27 basic Bessemer converters constructed in the United Kingdom, of which, however, only 47 acid and 17 basic were employed. It thus appears that not much over half of the total plant in the country was employed, and that half in some cases very irregularly.

Bessemer steel is being used more largely for merchant bars, railway sleepers, castings, and plates, while it is in demand to a less extent for tires and axles. A good deal of the steel is produced and sold, both for home consumption and for export, in the form of blooms and billets. The manufacturers of wire, springs, hoops, fish-plates, etc., do not as yet make use of it to any extent, and a good deal of the demand for these articles continues to be met by the finished-iron manufacturers of Staffordshire and Lancashire. The old Yorkshire iron, too, appears to hold its own, as Lowmoor and the other works engaged in its production are less depressed than most other branches of the trade.

Open-hearth Steel.—The extensive application of this variety of steel to the production of ship plates and of tin-plate bars has caused the industry to develop very rapidly in Scotland, South Wales, and the Cleveland district. In 1880 not more than 99 furnaces had been built, and the production of open-hearth ingots in that year was only 251,000 tons. Ten years later the number of furnaces had grown to 329, and the production of ingots to 1,564,000 tons. The make of open-hearth steel showed a decline in 1891, for the first time in its history; but the decline was not a serious one, amounting to only 49,662 tons on a production of 1,564,200 tons. In the first half of 1892 the open-hearth steel trade showed a decline of 56,547 tons compared with the output of the first half of the previous year, the total quantity of ingots produced having been 722,341 tons as against 778,888 tons. The total number of open-hearth furnaces at work during the first half of 1892 was 212½, while 26 basic furnaces were employed, the total number of furnaces for the kingdom being 310 acid and 32 basic. The principal works of this description are in Scotland, but of late years Cleveland has also been coming largely to the front, and the largest individual production of a single company appears now to rest between the Consett Iron Company in Durham and the Steel Company of Scotland at Glasgow.

Basic Steel.—During the last five years the production of basic steel has been increased and the quality has been much improved. The difficulty of having the steel accepted by the British Admiralty and by *Lloyd's Register* for shipbuilding purposes hindered the industry for a while, but has now been overcome, basic steel having to all intents and purposes been placed on the same footing as acid. This, no doubt, will give the basic steel trade a considerable impetus. The production of basic steel of both descriptions in the year 1891 and for the first half of 1892 was as follows: Year 1891, Bessemer, 335,776 tons; open-hearth, 100,486 tons. First half of 1892, Bessemer, 105,417 tons; open-hearth, 61,104 tons.

During the year 1892 the patentees of the basic process made an application before the judicial committee of the Privy Council to have the term of the patents

extended, on the ground that the result so far had been inadequate and for other reasons, but the application was not granted.

Manufactured Iron.—Although the tendency during recent years has been for manufactured iron to become displaced by steel, yet the singular fact remains that the manufactured iron industry is not only still alive, but it actually appears to enjoy a greater amount of prosperity, where it is carried on successfully, than steel. Only three years ago it was ascertained that the total production of puddled bar in the United Kingdom was 2,225,000 tons, which was probably as much as had ever been produced in the history of the trade, except in the years 1881 and 1882, when it was somewhat higher. But in the following year (1890) this output had fallen off to the extent of 330,535 tons, and in the year 1891 there was a further decline of 189,319 tons. No general statistics appear to be available for a later date, but the returns submitted to the Board of Arbitration in the manufactured-iron trade of the North of England show that the course of the trade during 1892 has been unsatisfactory, alike as regards production and prices. Within the last three years there has been a great accentuation of the reduced demand for iron plates and sheets, and many puddling furnaces have been dismantled. It is somewhat curious that in Continental countries also the manufactured-iron trade appears to hold its own.

In Great Britain the principal center of this industry is South Staffordshire, where, however, the output of 1890 and 1891 was largely downward. Many small forges are scattered up and down this county, but the number at work, of any size, is comparatively limited. Hoops, bars, rounds, and squares are the principal products of the works of this district. In the Cleveland district, which takes the second rank, the production of puddled bars in 1891 was about 150,000 tons behind that of Staffordshire; but as the shipbuilding trade has been rather depressed in the past year, it is probable that this has been reduced still further. Cleveland chiefly produces ship plates and angles, together with bar iron. Scotland and Lancashire take the third and fourth places among the manufactured-iron centers of the country, but are still a long way behind the other districts named. Iron rails are produced to a very limited extent, mainly for local colliery lines, and boiler plates continue to be made of the famous irons of Lowmoor, Monkbridge, and Bowling.

Prices of Iron and Steel.—The general tendency of the prices of iron and steel during the past ten months has been toward a notable reduction. This has been specially marked in the case of railroad iron, in which there has been a fierce competition. Indeed, the average price of rails over the year will not have been more than £4 5s., even if so much. The course of prices for plates and angles has not been quite so depressed, inasmuch as the shipbuilding trade, although dull, has been better than the rail trade. The following tables show the mineral production from 1860 to 1891, and the imports and exports from 1876 to 1892, both inclusive.

MINERAL IMPORTS OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

Years.	Brimstone.		Chemical Mfs. and Products.	China, Porcelain, and Earthenware.		Glass of all Kinds.		Guano.		Copper Ore and Regulus.	
	Tons.	Dollars.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1877..	55,148	1,587,980	5,282,330	29	1,825,595	58,003	9,540,835	155,487	8,325,635	151,764	11,849,920
1878..	44,448	1,206,185	4.963,755	37	2,204,810	62,106	10,250,665	180,696	9,032,865	131,888	10,223,850
1879..	41,688	1,012,945	4,449,190	40	2,163,120	58,372	7,870,895	78,272	3,522,240	136,163	11,304,170
1880..	47,140	1,253,475	5,696,675	48	2,342,815	64,845	8,882,365	82,268	4,050,885	147,850	12,911,670
1881..	41,228	1,208,980	6,934,885	61	2,774,065	65,208	8,371,205	51,936	2,456,635	149,593	12,138,805
1882..	48,044	1,462,310	7,596,005	68	2,981,010	68,070	8,396,625	45,686	1,942,335	154,551	13,049,180
1883 .	44,884	1,211,130	7,749,645	67	3,017,050	70,026	8,029,460	75,433	3,623,040	166,450	14,681,040
1884..	37,967	965.470	7,520,105	65	2,753,000	73,410	8,078,080	49,136	2,200,125	189,727	15,875,330
1885..	36,578	916,865	6,781,455	67	2,592,480	77,368	8,160,130	25,670	1,225,065	192,668	14,417,990
1886..	32,328	789,545	6,422,685	71	2,607,090	74,770	7,723,060	70,339	2,702,585	154,903	10,583,075
1887..	33,586	785,940	6,066,465	71	2,688,130	84,226	8,371,340	21,520	870,430	172,279	12,505.990
1888..	39,293	867,125	6,056,485	72	2,997,850	91,213	9,533,850	24,830	981,895	234,080	24,878,950
1889..	40,403	863,935	7,074,980	84	3,251,110	91,380	8,910,965	29,071	998,915	254,658	21,173,095
1890 .	25,886	647,490	7,209,545	84	3,166,395	107,242	10,424,325	27,537	822,255	219,461	14,554,840
1891..	21,767	647,485	6,845,365	94	3,366,560	120,149	11,497,880	24,008	693,210	217,497	20,297,540
1892..	21,789	738,905	7.583,280	.....	....	131,603	12,172,250	28,331	947,165	229,774	19,386.895

Years.	Unwrought, Part Wrought, and old Copper.		Iron Ore.		Iron in Bars.		Iron and Steel, Wrought and Manufactured.		Lead.		Manganese.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1877..	44,192	15,316,145	1,160,973	6,280,345	93,317	4,889,850	85,572	7,685,315	96,029	10,084,015	13.391	339,390
1878..	43.603	13,698,925	1,192,584	5,814,255	104,490	5,090,610	107,218	8,548,230	101,777	9,088,645	9,989	201,125
1879..	50,561	14,623,545	1,102,774	5,250,835	97,110	4,391,785	114,154	8,608,505	103,757	7,655,190	12,371	229,365
1880..	40,389	12,855,360	2,675,618	13,949,645	121,982	6,073,130	157,983	12,127,610	96,602	7.814,795	16,348	335,350
1881..	35,096	10,831,915	2,490,742	11,747,055	113,333	5,702,545	178,211	12,824,115	95.087	6,940,545	19,049	350,745
1882..	38,400	12,611,965	3,388,200	15,315,455	141,504	6,982,285	175,030	12,379,490	89,288	6,334,995	30,252	511,335
1883..	38.716	12,068.915	3,243,215	13,754,350	124,903	6,183,675	197,174	14.354,065	103,377	6,526,940	22,727	411,570
1884 .	42,925	11,645,875	2,775,450	10,573,000	117,373	5,829,740	188,146	13,467,110	110,797	6.111,625	26,474	377,175
1885..	44,716	10,165,790	2,868,719	14,785,995	124,600	6,100.950	176,586	11,806,920	109,868	6,053,840	48,358	810,420
1886..	45,923	9,421,505	2,925,503	9,473,130	107,189	4.785,285	179,773	11,001,325	109,624	6,866,510	74,623	1,199,110
1887..	31,520	6,627,795	3,827,330	12,739,750	114,813	4,949,290	201,611	11,785,090	116,363	7,232,065	91,859	1,366,185
1888..	48,189	18,054,350	3,620,275	12,349,445	115,024	5,127,840	230,342	13,494,765	135,051	9,247,115	73.266	1,005,510
1889..	42,017	10,602,820	4.097,135	15,123.025	113,605	5,169,870	234,136	15,045,240	147,575	9,376,435	97,606	1,407,230
1890..	52,878	14,289,210	4,514,859	17,980,280	94,416	4,626.590	226,415	15,967,985	161,241	10,495,230	142,464	2.173,690
1891..	47,242	12,226,245	3.232,513	12,267,035	78,692	3,757,935	232,822	16,373,005	172,497	10,688,375	103,107	1,627,225
1892..	35,680	8,277,700	3,840,373	13,577,100	77,155	3,461,275	221,943	15,173,460	185,768	9.882,436	.. ..	*

* Other metals not enumerated in 1892 were imported to the value of $24,037,360.

Years.	Silver Ore.	Quicksilver.		Tin in Blocks, Ingots, Bars, and Slabs.		Zinc, Crude, in Cakes.		Zinc Manufactures.		Paraffine.	
	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1877..	2,812,685	1,631	1,815,210	13,983	4,806,995	35,870	3,615,900	16,367	2,080,675	1,165	311,665
1878..	2,648,925	1,466	1,514,595	16,931	5,205,130	33,257	3,050,105	16,474	1,929,315	2,468	665,295
1879..	3,622,575	1,802	1,723,655	17,032	5,719,825	34,457	2,818,060	15,724	1,732,215	2,834	769,705
1880..	3,166,800	1,681	1,773,965	19,810	8,680,480	33,845	3,154,195	15,950	1,939,605	2,499	566.010
1881..	3,440,880	1,818	1,821,390	20,635	9,367,360	46,832	3.778,330	19,619	2.074,065	3,458	585,440
1882..	3,750,395	1,563	1,396.455	24,675	12,692,885	42,560	3,544,385	18,471	1,984,680	6,124	1,058,105
1883..	5,152,710	1,855	1,498,445	26,469	12,214,795	41,459	3,201.510	20,703	2,041,030	7,952	1.542,930
1884..	5,448,840	2,041	1,669,590	26,592	10,618,995	48,437	3,500,770	20,409	1,950,785	8,903	1.743,765
1885..	5,426,135	1,877	1,634,795	25,874	10,909,455	61.112	4,240,935	19,986	1,804,415	11,824	2,070,100
1886..	5,152,440	2,007	1,848,895	24,462	11,590,350	55,005	3.874,690	18,479	1,630,020	13,916	2,107,610
1887..	6,890,780	2,083	2,196,040	26,333	14,341,305	57,990	4,298,195	20.088	1,776,440	16.623	2,258,640
1888..	7,479,860	2,511	3,082,495	28,498	17,601,710	61,059	5,235,870	18,515	1,845,690	17,686	2,241,170
1889..	11,143,955	2,249	2,738,760	30,554	13,986,370	57,342	5,374,715	19,518	2,083,675	16,039	1,874,435
1890..	13,186,160	2,021	2,943,855	27,471	12,737,080	57,123	6,441,790	17,830	2,200,835	25,384	3,183,000
1891..	18,831,695	2,131	2,537,515	28,657	12,825,370	59,469	6,647,525	20,488	2,571,980	28,426	4,025,170
1892..	*	1,939	1,980,920	29,949	15.719,070	53,655	5,512,855	19,316	2,315,155	28,079	3,748,520

Years.	Petroleum.		Phosphate of Lime and Rock.		Pyrites of Iron or Copper.		Saltpetre.		Saltpetre Cubic Niter.		Stones, Marble, & Slate, Rough, Hewn, or M'f'd.	
	Gallons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1877..	33,866,311	8,882,530	....	....	690,413	8,218,070	13,628	1,491,425	72,028	4,789,140	366,559	3,182,515
1878..	30,255,526	6,061,630	....	....	588,725	6,680,235	14,209	1,474,400	105.716	7,736,755	374.011	3,125,110
1879..	43,280,291	6,912,670	....	....	489,258	5,252,725	15,466	1,451,960	56,567	3,902,080	307,478	2,272,595
1880..	38,757,371	6,546,395	....	....	668,799	7,613,620	13,850	1,510,525	46,525	3,507,465	303,116	2,471,680
1881.	59,237,258	9,762,220	....	....	551,240	6,011,405	13,933	1,406,530	55,891	4,024,520	306,397	2,321.340
1882..	59,695,982	8,605,095	*202,687	*3,065,990	637,957	7,113,420	16,365	1,753,555	97,327	6,351,760	334,354	2,676,995
1883..	70,526,996	10,851,490	250,980	4,069,125	611,113	6,780,415	15,166	1,430,935	104,673	5,853,030	385,201	2,895,110
1884..	52,975,879	8,556,565	222,807	3,219,255	572,273	6,224,355	16,959	1,530,565	103,212	4,896,305	375,935	2.731,385
1885..	73,873,641	11,447,625	242,470	3,140,135	665,216	6,263,115	16.503	1,365,370	114,232	5,575,160	344.522	2,600.280
1886..	71,251,736	10,456,380	226,756	2,634,425	566,089	5,149,195	13,766	1,200,330	76,275	3,729,700	392,766	2,745,320
1887..	77,390,435	10,517,995	288,046	3,070,440	606,525	5,327,340	15,299	1,297,830	88,364	4,168,605	379,002	2,747.095
1888..	94,401,285	12,827,990	262,099	2,724,595	629,056	5,896,275	17,840	1,494,120	104,377	4,924,470	379.191	2,888.455
1889..	102,881,256	12,944,735	309,936	3,518,520	654,872	6,058,955	16,841	1,455.105	119,473	5,512,915	405,644	3,127,290
1890..	105,080,863	11,985,935	349,114	4,247,260	667,625	6,097,440	15,895	1,413,345	110 578	4.518,160	516,434	3,320.590
1891..	130,615.360	13,426,840	260,968	3,141,975	626,297	5,631,235	14,168	1,255,105	124,033	5.249,090	435,067	3,074,545
1892..	130,188.085	12,234,530	... .	... .	614.238	5,317,530	11,134	1,249,135	120,579	5.062,745	....	....

* First reported in 1882.

EXPORTS OF MINERAL PRODUCTS OF THE UNITED

Year.	Alkali.		Gunpowder.		Bleaching Materials.		Cement.		Chemical Products and Dye Stuffs.	Clay.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Dollars.	Tons.	Dollars.
1877...	329,985	10,985,505	7,330	1,972,885	52,498	1,601,015	282,288	2,898,815	9,488,670	130,198	706,465
1878...	286,732	9,873,165	6,453	1,745,890	54,422	1,403,965	287,810	2,866,790	9,464,320	131,077	688,310
1879..	321,951	10,050,135	5,535	1,558,060	59,385	1,554,675	225,488	2,759,140	10,185,740	142,919	759,790
1880...	309,291	11,950,410	6,773	1,862,925	74,305	2,207,735	282,040	3,462,875	11,920,105	154,026	815,260
1881...	345,917	10,449,070	6,517	1,848,535	80,543	1,791,630	322,915	3,766,960	12,683,740	170,478	927,680
1882...	342,179	10,339,030	6,435	1,781,600	81,335	1,701,515	349,306	4,023,005	11,348,465	187,692	1,024,590
1883...	352,908	10,624,810	7,183	1,923,195	81,310	2,401,390	407,332	4,627,370	10,501,265	180,098	962,350
1884...	333,370	10,448,045	7,253	1,936,960	81,818	3,307,030	393,412	4,355,025	10,465,120	173,954	903,955
1885...	338,419	9,778,950	5,791	1,291,425	76,586	2,535,400	373,928	4,055,000	9,727,870	186,503	955,255
1886...	317,134	8,940,390	5,262	1,443,625	78,760	2,514,595	432,864	4,310,260	9,880,200	187,369	985,705
1887...	313,024	8,713,855	4,441	1,316,970	80,177	2,964,805	514,389	4,913,880	10,959,575	208,063	1,087,935
1888...	322,224	8,193,850	6,136	1,816,350	81,432	3,076,905	622,748	5,825,000	12,003,655	218,933	1,144,900
1889...	306,436	7,864,610	4,846	1,368,500	77,450	2,816,565	642,019	6,158,245	13,875,505	253,938	1,351,910
1890...	321,650	10,446,475	4,687	1,264,140	88,224	2,530,380	638,746	6,409,815	16,187,130	255,091	1,363,600
1891...	316,352	11,676,405	5,093	1,371,970	76,895	2,612,075	585,414	5,703,485	14,276,150	275,035	1,494,490
1892...	299,089	10,593,955	3,601	1,011,960	75,717	2,994,645	501,212	4,512,995	13,606,920	....	... .

Year.	Hard-ware and Cutlery.	Machin-ery.	Iron, Old.		Iron, Pig and Puddled.		Iron, Bar, Angle, Bolt, and Rod.		Iron, Railroad.		Iron, Wire.	
	Dollars.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1877	16,688.770	33,614,340	23,792	503,940	896,471	12,643,275	252,042	9,640,515	506,406	19,340.530	51,926	3,761,390
1878	16,489,685	37,489,795	32,886	619,880	938,163	12,350,810	227,527	8,031,065	446,571	16,456.675	44.394	3,153,175
1879	15,141.355	36,396,025	238,993	4,006.515	1,243,426	15,751,445	235,005	7,680,670	471.458	14,383,305	37.733	2,485,375
1880	17,604,390	46,317,580	247,594	5,825,345	1,695,015	26,093.300	309,184	11,881,895	705,031	25,361,765	60.147	4,139,525
1881	19,404,160	49,851,050	125,747	2,440,235	1,506,575	20,523,880	299,171	10,065,665	834,211	28,332,230	76,356	5,004,220
1882	20,535,625	59,661,235	134,190	2,535,805	1,786,799	24,810,925	318,271	11,492,665	952,259	31,936,095	88,069	6,652,720
1883	18,782,245	67,165,405	99,067	1,689,975	1,589,605	20.387,780	292,981	10,173,335	987.033	30,071,320	63,643	4,633.985
1884	15.713,555	65,367,320	69,254	1,117,110	1,290.321	14,726,115	301,333	9,711,470	740,444	28,710,315	53,833	3,463.035
1885	14,259.600	55.434,345	86,628	1,307,175	976.632	10,464,080	268,793	8,102,420	725,947	14,526,295	55.993	3,446,690
1886	14,227,805	50,684,195	147,227	1,942,450	1,177,099	11,272,485	246.916	6,865,355	751.688	18,436,910	41,000	2,791.915
1887	14.605,795	55,629,290	294,039	4,138,775	1,061,619	13,684,330	267,852	7,244,295	1,028.311	23,089.595	47,222	3,154,990
1888	15,842,015	64,696,335	147,340	1,984,905	1.053,252	11,031,865	302,388	8,291,540	1,036,668	23,346,075	65,161	4,315,740
1889	14,945,940	76,419,550	149,116	2,160,975	1,209,821	14,941,620	256,505	8,122,880	1,107,700	26,654,290	56,809	4,161.145
1890	13,822,230	82,053,305	152,351	2,511,115	1,163,982	17,492,840	226,476	8.294,000	1,052,349	29,908,445	62,573	5,415,375
1891	12.637,875	79,087,575	112,882	1,771,845	'853,781	11,027,835	220.668	7,314,500	713,763	19,263,820	68.619	5,715,635
1892	11,037,865	73,993,580	108,308	1,639.285	779,900	9.882,450	175,673	5,720,810	475.000	11,238,205	48,239	3,975,995

Year.	Copper, Ingots, Cakes and Slabs.		Copper, Wrought or Partly Mixed or Yellow.		Copper, Wrought or Partly Wrought, all other sorts.		Brass.		Lead, Pig, Sheet, and Pipe.		Tin, Unwrought.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
1877.	11,775	4,381,290	17,342	6,035,365	11,416	4,875,510	4,668	2,203,100	43,158	4,562,490	6,196	2,244.320
1878.	17,688	6,068.205	12,653	4,523,895	11,827	4,892,085	4.997	2,047,470	34,946	3,222,280	6.314	2,066,265
1879.	17,033	5.307,205	17.005	4,693,200	15,432	5,411,990	4,021	1.543.530	37,363	2.834,830	6,323	2,241,765
1880.	15,700	5,268,015	17,209	5,109,835	16,850	6,289,990	3,880	1,617,365	34.099	2.920,140	4,490	1,995.875
1881.	19,036	6,141,890	16.919	5,018,400	15,990	6,022,500	4,732	1,923,960	43.696	3.379,140	4,877	2,302,530
1882.	12,930	4,546,205	18.445	5,753,110	15,955	6,371,075	5,050	2,221,915	37,985	2,886,625	5,615	2,897.785
1883.	16,206	5,715,170	20,086	5,908,330	16,339	6,223,865	4,907	2,160.165	39,957	2,765,720	5,458	2.620,245
1884.	18,217	5,265,675	19,647	5,277,880	21,024	7,296,590	5.427	2,264,990	34,099	2,110,890	5,579	2,346.050
1885.	19.072	4,505,545	21,361	4,860,970	21.410	6,162,520	4.676	1,817.075	39,175	2,360,325	4,725	2,059,930
1886.	19,331	4,168,050	20.182	4,066,115	18,208	4.653,040	4,353	1,602,460	43,057	2,933,850	4,769	2,362,385
1887.	21,723	4,837,330	17,189	3,511,030	19.592	4,974.870	4,559	1,684.480	45,025	3,035,390	4,991	2,689 320
1888.	25,608	9,784,585	7,629	2,474,365	6,963	2,842,785	3,841	1,853.795	49,410	3,644,590	6,138	3,508.880
1889.	33,067	7,684,585	15,573	4,087,150	15,712	4,662,315	5,468	2,430,245	52,890	3,789,150	5,516	2,613,750
1890	45,762	13,146,070	17,859	5,024,150	13,767	4,587,550	5,396	2,505,290	56,464	4,061,650	5,214	2,516,855
1891.	35,936	9,823,740	14,299	3,932,575	16,423	5,384,245	5,792	2,583,030	49,021	3,412,395	5,273	2,457,460
1892.	42,994	10,310,435	14.996	3,651,555	16,482	4,865.550	5.492	2,263,115	59,050	3,537,865	5.740	2,721,880

KINGDOM OF GREAT BRITAIN AND IRELAND.

Coals, Coke, Cinders, and Fuel.		Earthen and China-ware.	Glass, Plate.		Glass, Flint.		Glass, Common Bottles.		Glass, other.		Year.
Tons.	Dollars.	Dollars.	Sq. Ft.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	
15,672,013	39,222,430	10,206,205	1,157,063	643,315	4,887	1,341,145	31,139	1,683,770	4,244	604,115	..1877
15,747,815	36,652,370	9,845,395	1,154,701	533,810	4,718	1,198,735	29,445	1,551,535	3,665	495,340	..1878
16,710,963	36,033,995	9,878,720	1,691,445	668,175	4,483	1,252,685	30,445	1,528,030	5,556	566,275	..1879
19,025,855	41.864,665	11,282,105	2,380,400	963,035	5,700	1,243,470	33,512	1,914,430	6,825	736,605	.1880
19,907.115	43,929,750	11,982.855	2,809,990	1,064,750	6,736	1,462,530	32,643	1,592,910	6,506	655,595	..1881
21,276,516	47.823.080	126,556,035	3,610,350	1,379.545	6,336	1,480.205	39,953	1,876,165	6,995	692,480	..1882
23,147,787	53,229,595	12,810,440	3,677,314	1,306,800	7,668	1,695,230	39,087	1,782,480	8,884	637,660	..1883
23,732,672	54,255.650	10,830,150	3,762.183	1,364,415	6,530	1,507,845	38,575	1,764,175	7.175	622,410	..1884
24,159,374	53,165,755	10.026.390	3,886,894	1,231,150	6,687	1,398,345	37,199	1,751,965	5,489	449.595	..1885
23,663,839	49.686,690	10.364,065	4,402.132	1,201,835	5.514	1,297,030	38,141	1,780,335	7,440	572,685	..1886
24,860,659	50,849,955	10,793,330	4,697.143	1,313,400	4,946	1,183,445	41,998	1.952,925	8,637	655,375	..1887
27,411,234	56,726,495	11.585.930	4,349,198	1,404.335	6,550	1,418.370	43,889	2,025,830	10,412	798,170	..1888
29,429,593	73.909,950	12,677.245	3,896,673	1,215,635	6,158	1,375,295	49,925	2,323,710	11,027	822,035	..1889
30,635,372	95,101,345	12,572,365	3,070,456	951,090	5,684	1,305,525	47,512	2,166,450	10,340	903.600	..1890
31,592,030	94.475,390	11,868.450	3,284,513	1,062.010	5,565	1,214,690	40,206	1,856,270	10,874	933.515	..1891
30.955.110	84,055.350	10.213,175	2.158.046	582.845	4.820	1,135.280	38,336	1,804,405	11,202	909.655	..1892

Iron, Hoops, Sheets, and Boiler.		Iron, Tinned Plates.		Iron, Cast or Wrought.		Steel, Unwrought.		Steel Manufactures.		Year.
Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	
203.387	13,661,565	155,730	15,165,630	258,768	18,228,305	24,799	4,039,250	11,506	3,585,175	..1875
196.139	12,655,135	157,777	13,661,890	254,578	17,560,515	24,525	3,792,855	11,828	3,684,200	..1877
195,722	10,541,630	200,216	17,539,885	265,159	17,167,660	31,568	4,091,005	11.319	3,438,325	..1878
288.721	11,415.600	221,276	22,289,435	280,219	18,960,640	70,176	6,349,930	14,497	4,134,095	..1889
309,907	17,023,950	247,348	20,815,660	296.612	19,821,340	170,159	9,355,805	16,640	4,571,555	..1880
348,197	19,719.030	269,370	23,210,625	333,625	22,749,300	75,145	10,171,695	18,762	4,712,670	..1881
353,465	19,498,870	273,777	23,527,015	361,656	23,083,300	74,326	6,982,780	13,821	2,903.220	..1882
353,989	18,465,005	293,329	23,734,615	382,516	22,903,355	57,864	5,637,405	11,245	2,011.950	..1883
334,574	16,340,715	303,261	22.138 475	353,648	20,065,540	61,469	5,137,300	13,099	5,525,500	..1884
312.784	15,315,725	340,160	23,692,940	359,706	19,285,215	169,085	7,468.345	13,672	2,017,260	..1886
356.777	16,573,785	359,282	23,964,270	375,341	20,612,575	291.005	10,466,375	13,801	2,032,580	..1887
418,078	20.231,090	397,756	27,731,140	435,107	24,426,275	55,754	7,863,770	19,868	2,860,930	..1888
392,026	20,668,335	437,687	30,150,025	471,100	27,157,110	152,330	8.495,050	21,486	3,199,315	..1889
341,076	19,200,710	428,689	31,807,385	461,592	29,827,865	151,856	9,511,540	25,866	3,856,910	..1890
326,618	17.803,245	455,705	35.833,275	370,865	24,032,005	152,910	8,660,365	17,316	2,962,475	..1891
143,947	6.347,280	402,065	26,670,290	325,357	21,802,140	150,937	8,697,700	15.341	2,471,960	..1892

Zinc, Wrought and Unwrought.		Plate and Plated Ware.	Salt.		Slate by Tale.		Stones, Grindstones, Millstones, etc.		Telegraphic Wire and Apparatus.	Year.
Tons.	Dollars.	Dollars.	Tons.	Dollars.	No.	Dollars.	Tons.	Dollars.	Dollars.	
5,871	598,965	1,104,260	847,322	2,312,875	37,565,282	1,472,575	35,692	626,450	6,230.720	..1877
6,773	600,880	1,091,405	830,508	2,514,045	2,426,850	1,023,180	24,524	489,275	3,729,760	..1878
5,764	429,860	1,048,100	975.324	2,759,745	27,801,100	914,575	26,687	461,910	12,503.185	..1879
8,151	622,880	1,167,490	1,008,410	3.019,590	31,189,500	882,665	31,571	417,850	6,504,540	..1880
7,916	591,480	1,393,665	1,022,670	2,929,190	38,415,100	1,063,495	23,331	386,345	9,918,315	..1881
8,727	629,845	1,754,375	971,752	2,843,575	47,366,300	1.251,130	27,831	483,420	5,212,805	..1882
7,220	493,705	1,700,840	1,020,723	3,225,045	34,544,400	961,285	20,427	467,525	6,189,465	..1883
7,501	501,780	1,605.985	962,900	3,057,685	49,035,600	1,259,120	26.035	504,155	12,545,715	..1884
7.811	510,660	1,640,035	936,929	3.362,135	45,482,000	1,212,420	22,350	455,850	3,850,270	1885
8,506	568,345	1,841,960	817,957	2,939,810	43,389,700	1,138,240	86,093	571,455	4,963,335	..1886
10,716	733,515	1,698.990	832,093	2,624,300	42,920,800	1,148,545	31,967	612,660	4,086,925	..1887
5,678	438,365	1,959,945	913,361	2,429.575	44,571,400	1,247,555	45,486	806,575	2,605,275	..1888
6,749	519,170	2,191,160	677,677	2,692,570	53,274,700	1,394,200	49,964	924,470	5,192,700	..1889
8,342	813,390	2,018,970	737,891	3,263,355	50.409,600	1,381,130	58,896	995 325	8,011,025	..1890
7,799	808.665	1,953,275	682,235	2,982,040	48,477,000	1,310,515	32,888	797,365	7,170,100	..1891
10,001	897,935	1,609.995	664,432	2.694,915	....	....	....	....	4,550,350	..1892

MINERAL PRODUCTION OF THE UNITED

Metric tons

	Alum Shale.		Arsenic.*		Arsenical Pyrites.		Barytes.		Bauxite.		Clays.†	
	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$
1860...	no returns	....	1,626	64,000	no returns	....	13,573	48,750	no returns	....	517,005	1,105,750
1861...	"	....	1,474	54,375	"	....	11,639	not given	"	....	701,926	1,159,005
1862...	"	....	915	4,100	"	....	10,130	"	"	....	867,800	1,363,995
1863...	"	...	1,468	6,000	"	....	no returns	....	"	....	834.122	1,327,210
1864...	"	....	643	2,375	"	....	508	1,835	"	....	1,133,862	1,841,575
1865...	"	....	841	3,020	"	....	6,880	24,980	"	....	1,144,382	1,869,580
1866...	"	....	1,135	6,505	"	....	1,783	....	"	....	1 168,575	1,962,875
1867...	"	. ..	2,292	20,560	"	....	11,289	39,035	"	....	1,198,633	2,948,250
1868...	"	....	3,354	48,550	"	....	14,468	43,640	"	....	1,029,077	1,588.850
1869...	"	....	2,603	57,320	"	....	6,085	17,075	"	....	1,219.672	2,250,000
1870...	"	....	4,116	88,695	"	....	6,622	18,855	"	....	1,219,672	2,250,000
1871...	"	....	4,216	77,595	"	....	5,602	17,695	"	....	1,275,574	2,375,000
1872...	"	....	5,257	89,820	"	....	9,242	35,390	"	...	1,219,672	2,250,000
1873..	"	....	5,538	114,270	"	....	10,438	39,965	"	....	1,814,262	3,281,500
1874...	"	....	6,371	137,190	"	...	14,610	61,505	"	....	2,476,861	3,900,795
1875...	"	....	5,144	155,870	13,160	not given	15,804	70,445	"	....	3,057,763	3,769,785
1876...	4,592	not given	4,297	140,460	13,161	"	23,948	122,395	"	....	4,036,223	3,721,120
1877...	20,059	"	4,888	152,105	5,429	"	21,401	144,740	2,808	not given	3,009,699	2,951,155
1878...	6,843	"	5,073	134,500	3,698	"	22,804	183,430	3,482	"	2,755,937	3,389,355
1879...	4,164	"	5,582	170,900	2,639	"	19,667	105,340	3,717	"	2,925,677	3,585,715
1880...	6,805	"	5,832	217,490	5,273	"	18,780	66,920	3,527	"	3,112,750	8,178,250
1881...	7,787	"	6,257	225,350	14,556	"	21,647	119,470	7,839	"	2,440,789	6,001,050
1882...	8,580	5,275	7.591	245,740	12,770	58,070	23,690	139,350	8,527	29,385	2,903,100	3,857,855
1883...	8,424	5,180	7,747	267,565	1,321	5,460	21.730	132,825	13,699	50,540	2,900,129	3,533,785
1884...	1,992	1,225	8,035	289,205	1,791	5,715	20,391	146,780	8,700	21,400	2,739,902	3,336,980
1885...	2.362	1,460	8,262	284,285	1,942	7,865	26,583	151,480	9,178	18,285	2,572,693	3,004,670
1886...	3,041	1,870	5,109	164,010	4,999	38,745	25,554	129,090	8,397	12,390	2,429.628	2,916,050
1887...	2,628	1,615	4.694	162,290	4,436	16,025	25,220	133,095	4,237	5,200	2,453,262	2,952,060
1888...	2,017	1,240	4,700	175,985	5,412	21,200	25,604	130,735	9,824	24,165	2,604,805	3.267,095
1889...	4,257	2,615	4,836	191,300	7,814	36,585	25,256	141,190	9,300	27,450	3,086,028	4,140,870
1890...	6,525	4,010	7,395	303,635	5,198	22,070	25,769	148,420	11,716	28,815	3,362,447	4,495,830
1891...	5,564	3,420	6,147	292,965	5,179	21.850	27,317	160,600	10,939	16,140	3,274,855	4.719,480

* White arsenic, crude and refined, produced from arsenical pyrites not included in the next column.

UNITED KINGDOM.—ANNUAL OUTPUT,.

	Iron Ore.		Iron Pyrites.		Lead Ore.		Manganese ore.		Ochre and Umber.		Oil Shale.	
	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$
1860	8,155,749	12,334,645	137,893	420,695	90,541	6,183,745	947	15,480	607	4,345	no returns	....
1861	7,333,807	11,511,855	127,186	398,575	92,183	5,681,245	932	14,625	3,065	15,080	....	....
1862	7,686,211	11,998,695	100.047	291.065	96,874	5,957,000	....	.. ....	not given	25,000	....	....
1863	9,250.758	16,204,450	96,940	310,175	92,780	5,967,650	....	... .	4,497	23,880	....	....
1864	10,229,888	16,835,720	96.006	290,485	95,981	6,748,025	508	not given	2,362	10,890	....	... .
1865	10,072.505	16,624,020	116,067	355,870	92,098	5,765,670	....	... .	no returns	....	....	....
1866	9,823,455	15,595,490	137,622	389,660	92,540	5,806.140	....	....	5,114	15,245	....	....
1867	10,185 338	16,050,490	118,805	337,265	94,964	5,790,330	821	16,160	5,582	29,040	....	... .
1868	10,335.941	15,983,000	77,738	268.180	96,797	5,753,840	1,728	38,250	6,802	31,860	....	.....
1869	11,697,189	18,662,800	77,193	205.115	98,455	5,945,150	1,584	39,285	5.802	24,715	......	....
1870	14,606,238	24,756,100	59,386	180,130	99,785	6.001,045	4.917	97,495	4,923	21,305	....	....
1871	16,602,673	38,352,860	62,989	324,935	95,523	5.778,850	5,639	114,790	708	6,950	....	....
1872	16,855,740	38,874,370	65,980	197,350	85.345	5,730,825	7,901	194,325	3.382	41,135	... .	....
1873	15,832,868	37,868,380	59,831	177,425	74,705	5,659,535	8,813	288,830	6,472	27,050	532,687	1,310,235
1874	15,088,295	36,590.845	57,129	191,130	77,451	5,120,535	5,873	146.000	7,239	47,390	368,694	906,865
1875	16,080.422	29,877,050	48,823	175,680	79,021	6,010,740	3,258	79,530	5,403	35,925	449,587	1,000,000
1876	17,117,676	34,128,525	49,610	219,350	80,393	6,090,390	2,843	48,915	3,867	22,390	620,798	1,599,265
1877	16.966,455	33,733,340	44,668	141,130	82,175	5.619,760	3,087	39,790	5,157	22,440	713,204	1,754,250
1878	15,984,180	28,047,535	30,157	95.495	78,618	4,007,140	1,612	15,605	4.487	20,190	801,633	1,971,760
1879	14,615,468	24,812,175	20,608	59,180	67,973	3,443,700	829	7,575	4,039	17,185	797,206	1,960,870
1880	18,322,543	32,929,030	32,227	115,020	73.429	4,081,840	2,886	28,005	6,226	57,560	851,539	2,094,510
1881	17,732,066	31,005,340	44,327	150,165	65.763	3,281,625	2,931	32,105	8.097	61,430	973.964	2,395,635
1882	18,327,563	28,896,425	25,820	72,295	66,067	2,963,050	1,573	19,535	9,018	81.805	1,047,815	1,553,425
1883	17,668,014	25,611,905	28,125	87,335	57,413	2,374,555	1,308	14,880	17,447	129,795	1,187,090	1,498,380
1884	16,402,443	22,316,375	29,581	90,695	55,378	2,007.775	924	7,150	9,342	94.880	1,543,770	1,933,900
1885	15,670,736	19,848,595	30,350	92,585	52,143	2,038,000	1,716	12,055	13.546	117,295	1,799,436	2,236,510
1886	14,341,325	17,567,575	28,283	82,875	54,296	2,356,475	12,972	54,465	12,595	110.925	1,756,839	2,179,815
1887	13,312,763	16,166,775	22,441	63,410	52,408	2,145,685	14,000	55,550	8,429	78,945	1,434,515	1,775,425
1888	14,829,905	17,506,585	23,876	56,510	52,099	2,191,915	4,413	9,670	7,697	66,935	2,110,509	2,595.350
1889	14,784,566	19,241,340	18,009	40,555	49,260	2.148,235	8,997	32,390	10,666	77,660	2,047,890	2,518,575
1890	14,066,681	19,632,225	16,281	35,330	46,399	2,030,820	12,646	33.665	19,381	87,375	2.248,516	3,041,845
1891	12,987,159	16,779,300	15,716	40,010	44,578	1,783,915	9,632	31,065	13,825	100,515	2,399,826	3,535,885

NOTE.—In addition to the above, small quantities of the following minerals are occasionally produced, viz., steatite, and uranium ore. A very large quantity of stone used for building and other purposes is also ascertained, but the value in 1890 was estimated to be upwards of $43,540,000. Details concerning the mineral

KINGDOM OF GREAT BRITAIN AND IRELAND.

of 2204 lbs.

Coal.		Cobalt and Nickel Ore		Copper Ore.		Copper Precipitate.		Fluor-spar.		Gold Ore.‡		Gypsum.		
Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	
81,354,873	100,053,370	6.09	1,270	240,576	7,535,665	no returns	......	no returns	...	....	......	no returns	......	.1860
85.006,283	104,544,015	.81	120	235,282	7,135,075	"	......	"	....	....	.....	"	......	.1861
82,976,671	102,047,920	....	.....	227,846	6,083,875	"	......	"	....	816	75,000	"	......	.1862
87,706,842	102,864,725	....	.....	214,405	5,502,770	"	......	"	....	391	7,500	"	......	.1863
94,308,986	115,989,840	....	.....	218,122	5,777,355	"	......	1	60	2,374	......	"	.....	.1864
99,759,613	122,688,230	....	.....	201,549	4,639,690	"	......	56	230	4,350	......	"	.....	.1865
103,296,618	127,038,175	....	.....	183,333	3,795,590	"	......	2	10	2,973	...	"	......	.1866
106,213.603	130,625,725	1.88	75	161,143	3,498,465	"	......	....	....	3,294	26,600	"	......	.1867
104,831,996	128,926,445	....	.....	159,914	3,210,515	"	......	61	210	1,211	5,000	"	......	.1868
109,188,664	134,284,410	....	.....	132,083	2,599,560	"	......	....	....	....	......	"	.....	.1869
112,241,539	138,038,990	.61	135	108,447	2,189,255	"	......	....	...	....	......	"	......	.1870
119,275.832	176,028,040	5 08	1,090	98,721	1,935,590	"	......	52	130	....	......	"	......	.1871
125,521,862	231,555,715	1.02	100	93,491	2,218,890	"	......	81	120	....	......	"	......	.1872
130,789,643	241,275,245	.3	60	81,503	1,713,540	61	not given	....	....	....	......	67,208	not given	.1873
128,665,356	232,081,860	....	.....	79,808	1,682,070	178	"	643	1,585	...	......	62,115	"	.1874
135,491,837	233,286,350	....	.....	72,701	1,667,070	214	"	365	940	32.52	500	66,135	"	.1875
136,323.939	234,719,040	.36	.....	80,551	1,585,930	783	"	342	1,150	....	90	62,753	92,855	.1876
136,379,640	234,814,940	27.44	1,210	74,340	1,311,355	638	"	224	185	....	......	75,120	110,860	.1877
134,786,031	232,071,110	101	3,085	57,013	1,007,170	541	"	398	665	....	......	76,136	112.360	.1878
135,912.531	234,010,685	119	4,165	51,869	886,915	368	"	1,285	2,110	.2	.....	63,467	93,665	.1879
149,378,744	312,309,990	49.8	1,485	52,972	953,340	335	"	466	1,750	.1	125	76,689	125,650	.1880
156,711,911	327,641,635	65.05	1,550	53,418	950,285	597	"	379	1,270	.05	90	80,802	116,645	.1881
159,065,550	220,592,045	38.6	1,205	53,676	1,033,690	434	18,290	147	1,345	....	.....	103,542	290.715	.1882
166,421,545	230,270,715	49.8	865	47,047	729,520	540	18,505	91	1,265	.4	500	101.183	216.075	.1883
163,393,136	217,230,915	67.08	1,185	42,412	547.135	428	15,930	590	3,650	....	......	111,724	227.205	.1884
161,963,736	205.697.040	111	2,110	36,835	398.815	140	5,745	430	2,455	....	......	113.915	238,765	.1885
160,100,752	190,729,650	102	2,630	18,503	192,835	419	14,155	284	2,060	....	......	120,796	222,310	.1886
164,777,514	195,464,150	157	4,500	9,228	104,910	285	15,375	288	1,925	.86	1,045	122,763	241,465	.1887
172,721,042	214,856,380	155	3,730	15,380	304.900	425	32,695	142	765	3,907	136,500	132,215	294,990	.1888
179,816,998	280,877,130	158	4,840	9,177	132,920	286	15,565	302	2,055	6.328	53,730	134,527	269,095	.1889
184.594,850	374,769,985	85.37	1,300	12,333	139,005	351	23,350	272	1,260	584	2,070	142,592	289,955	.1890
188,519,767	370,499,080	Nil.	.....	8,981	101,070	327	21,775	143	935	14,348	62,000	154,195	300,190	.1891

† China clay, potter's clay, fuller's earth, etc., but exclusive of ordinary clays. ‡ Auriferous quartz.

ETC., OF MINERALS: (*Continued*).

Phosphate of Lime.		Salt.*		Slates and Slabs.		Sulphate of Strontia.		Tin Ore. ("Black Tin.")		Wolfram.		Zinc Ore.		
Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	Tons.	$	
30,492	300.000	1,596.726	4,025,615	no returns	....	......	....	10,634	3,744,135	19.31	95	15,807	198,155	1860
38,118	375,000	961,942	2,484,365	"	....	.....	....	11,831	3,627,800	6.09	145	16,029	155,565	1861
no returns	....	997,690	2,331,295	"	....	......	....	14,359	4,215,910	12.2	315	7,620	80,250	1862
"	....	938,893	2,116,925	"	....	......	....	15,405	4,819,925	13.2	335	13,153	149,840	1863
"	....	953,207	2,168,740	"	... .	......	....	15,460	4,629,845	2.53	70	15,310	222,810	1864
"	.. ..	983,155	2.297,330	"	... .	......	....	15,943	4,337,175	2.03	55	18,135	262,390	1865
"	....	1,010.174	2.981,640	"	....	... ..	....	15,327	3,659.730	......	......	12,979	213,275	1866
37,607	351,500	1,417,800	4,184,815	"	....	......	....	13,872	3,473,670	10.16	310	13,710	206,700	1867
38,118	357,500	1,538,657	4,636,135	"	....	......	....	14,182	3,871.025	9.15	335	12,990	195,970	1868
no returns	... .	1,270,492	3,437,500	"	....	......	....	14,966	5,139,025	25.4	1,615	15,788	246,830	1869
35,574	250,000	1,513,867	3,723,625	"	....	.....	....	15,483	5 011,785	51.8	3,265	13,809	205.290	1870
37.100	255,000	1,530.409	3,764,300	"	....	......	.....	16,539	5.154,170	20.3	1,140	18,027	281,650	1871
35,574	250,000	1,320,964	3,273,740	"	....	......	....	14,500	6,230,675	89	4,965	18,847	369,755	1872
no returns	....	1,814,263	4,462,500	"	....	......	. .....	15,129	5,284,175	50.8	2,635	16,231	305,830	1873
152,114	1,951.450	2,344,390	5,766,065	154,481	not given	......	....	14,269	3,941,550	33.5	2,725	17,106	240,975	1874
254,222	3,140,000	2,354,625	5,791,610	155,795	"	......	....	14,224	3,678,030	46.8	1,910	24,371	375,550	1875
262,382	3,125,000	2,310,522	5,683,140	159,459	"	......	....	13,912	3,004,615	23.4	860	24,000	450,710	1876
70,137	1,000,000	2,779,836	7,522,250	174,961	"	......	....	14,374	2,863,815	15.23	750	24,806	430,755	1877
54,885	750,000	2,726,912	6,707,325	171,812	"	......	....	15,292	2,653,685	10.16	500	25,855	402,825	1878
34,521	368.750	2.600,308	6,395,920	145.204	"	......	....	14,905	2,933,040	13.2	600	22,564	407,655	1879
30,100	354,750	2,688,361	5,612,500	155,194	"	......	....	13,963	3,365,710	1.01	45	28,000	492,730	1880
32,016	433,140	2,315,896	5.745.550	165,002	"	......	....	13,109	3,487.220	54.9	2,720	36,109	550,215	1881
50,362	488,000	2,170,472	3,076,580	513,055	6,462,750	... ..	....	14,275	4,029,235	58.9	3,735	33,069	467,855	1882
50,393	508,645	2,362,863	3,348,800	506,227	6,231,660	......	....	14,706	3,675,945	113	7,215	30,215	464,475	1883
52,716	519,880	2,370,945	3,391,715	493,626	5,870,100	11,610	114,220	15,365	3.346,270	65	5,520	25,982	370,145	1884
30,492	250,000	2,243,875	3,903.075	476,642	5,878,860	9,961	24,500	14,612	3,311,950	380	23,995	25,072	335,000	1885
20,328	157,500	2,177,338	3,710,890	463,687	5,535,845	13,825	28,750	14,465	3,901,510	142	11,160	23,535	338,795	1886
10,056	79,150	2,229,917	3,661,600	471,946	5,594,090	15,418	37,920	14,422	4,394,155	54.9	6,345	25,862	380,910	1887
22,870	216,560	2,343,305	3,504,145	479,522	5,287,675	7,180	17,660	14,607	4,473,325	61	8,125	26,841	484,920	1888
20,328	191,250	1,978,407	4,451,820	465,951	5,240,715	6,074	14,940	14,033	3,646,065	.53	40	23,582	484,625	1889
18,295	147,500	2,182,045	5,500,070	441,473	5,136,175	10,444	25,690	15,155	3,912,460	106	8,340	22,402	549,450	1890
10,164	100,000	2.077,072	4,884,120	421,829	4,835,000	8,193	20,150	14.726	3,676,200	140	16,705	22,580	567,225	1891

* Rock salt and salt obtained from brine.

antimony ore, bismuth ore, bog-iron ore (used for purifying gas), jet, lignite, petroleum, plumbago, silver ore, annually raised, besides chalk, ordinary clay, gravel, etc., the total quantity of which cannot be accurately output will be found in the *Mineral Statistics of the United Kingdom*, published annually.

PRODUCTION OF CERTAIN METALS IN THE UNITED KINGDOM.

Metric tons of 2204 lbs.

Year.	Fine Copper, Tons.	Metallic Lead, Tons.	White Tin, Tons.	Zinc, Tons.	Silver from Lead, Kilos.	Year.	Fine Copper, Tons.	Metallic Lead, Tons.	White Tin, Tons.	Zinc, Tons.	Silver from Lead, Kilos.
1854	20,224	65,054	6,072	a	17,319	1873	5,326	55,127	10,035	4,544	16,669
1855	21,643	66,603	6,098	a	17,420	1874	5,307	59,740	10,005	4,543	15,787
1856	24,654	74,328	6,278	a	19,039	1875	4,668	58,376	9,771	6,823	15,108
1857	17,660	68,498	6,690	a	16,519	1876	4,771	59,612	8,639	6,750	14,986
1858	14,693	69.422	7,033	3,522	17,649	1877	4,559	62,410	9,655	6,384	15,418
1859	15,925	64,208	7,216	3,757	17,926	1878	4,017	58,971	10,271	6,412	13,022
1860	16,230	64,355	6,804	4,428	15,149	1879	3,519	52,481	9,688	5.645	10,343
1861	15,582	66,710	7,571	4,487	17,655	1880	3,722	57,882	9,064	7,279	9,161
1862	15,086	70,163	8,614	2,186	21,269	1881	3,938	49,383	8,757	15,192	9,560
1863	18,480	68,340	10,170	3,897	19,654	1882	3,521	51,153	9,308	16,394	11,548
1864	13,521	68,180	10,273	4,106	19,871	1883	2,297	44,130	9,459	13.826	10,665
1865	12,083	68,282	10,203	4,533	22,470	1884	3,405	40,732	9,731	10,081	10,097
1866	11,320	68,495	10,154	3,244	19,721	1885	2,818	38,405	9,484	9,938	9,936
1867	10,391	69,562	8,842	3,811	24,977	1886	1,496	40,129	9,465	9,036	10,088
1868	9,977	72,181	9,452	3,774	25,901	1887	903	38,511	9,434	9,920	9,930
1869	8,427	74.460	9,920	4,573	25,788	1888	1,480	38,194	9,392	10,166	9,964
1870	7,292	74.623	10,367	4,000	24,321	1889	920	36,187	9,058	9,546	9,490
1871	6,383	70,188	11,078	5,047	23,606	1890	941	34,140	9,752	8,692	9,043
1872	5,796	61,411	9,716	5.276	19,496	1891	952	32,733	9.503	9,037	8,673

STATISTICS OF SCOTCH PIG-IRON WARRANTS, FROM 1845 TO THE PRESENT DATE, PUBLISHED BY THE AMERICAN PIG-IRON STORAGE WARRANT COMPANY, NEW YORK.

Year	Extreme Prices. Highest. s.	d.	Extreme Prices. Lowest. s.	d.	Average No. of Furnaces in Operation.	Production, in Tons of 2240 Lbs.	Stock at End of the Year, in Tons of 2240 Lbs.
1845.	....		....		94	475,000	240,000
1846.	....		....		97	580,000	144,000
1847.	....		....		89	540,000	80,000
1848.	....		....		103	600,000	98,600
1849.	53	0	41	6	112	690,000	210,000
1850.	51	0	41	3	105	595.000	270,000
1851.	44	9	37	6	112	760,000	350,000
1852.	77	0	35	6	113	775,000	450,000
1853.	81	0	49	0	114	710,000	210,000
1854.	92	3	63	6	117	770,000	120,000
1855.	83	6	53	6	121	825,000	98,000
1856.	81	0	65	6	126	832,000	88,000
1857.	83	6	48	6	127	915,000	157,000
1858.	60	0	52	0	131	980,000	340,000
1859.	59	0	47	0	124	950,000	390,000
1860.	61	6	49	3	131	998,000	460,000
1861.	52	0	47	0	123	1,050,000	578,000
1862.	57	6	48	0	120	1,080,000	676,000
1863.	69	6	50	3	134	1,180,000	763,000
1864.	67	3	49	3	134	1,160,000	760.000
1865.	65	6	50	0	136	1,164,000	652,000
1866.	82	0	51	0	112	994,000	510.000
1867.	55	6	51	6	108	1,031,000	473,000
1868.	54	0	51	6	114	1,068,000	568.000
1869.	58	6	50	6	124	1,150,000	620,000
1870.	61	6	49	9	126	1,200,000	690,000
1871.	72	6	51	4½	126	1,160,000	490,000
1872.	137	6	72	0	115	1,090.000	194.000
1873.	145	0	101	3	123	993,000	120,000
1874.	109	0	71	6	96	806,000	96.000
1875.	77	0	57	6	117	1,050,000	170.000
1876.	66	6	55	9	116	1,103.000	363,000
1877.	57	10	51	6	103	982,000	505,000
1878.	52	4	42	3	90	902,000	679,000
1879.	66	10½	40	0	88	932,000	745.000
1880.	73	3	44	5	106	1,049,000	739,000
1881.	53	9	45	0	116	1,176,000	940,000
1882.	53	1½	46	7½	108	1,126,000	836.000
1883.	49	0	42	10	110	1,129,000	835,000
1884.	44	7½	40	10	95	988,000	821,000
1885.	43	11½	40	7½	90	1,003.000	1,050,000
1886.	44	7½	37	11	83	935,000	1,183,000
1887.	47	8	38	5½	80	932,000	1,228,000
1888.	43	6	37	1	84	1,028,000	1,244,000
1889.	64	10½	40	10½	84	999,000	1,035,000
1890.	66	3	43	4	66	798.333	613,445
1891.	59	0	42	1½	51	674.425	579,677
1892.	47	0	40	0	76	977,213	443,646

The production of steel in the United Kingdom during 1892 was as follows:

	Ingots.* Acid.	Ingots.* Basic.	Ingots.* Total.	Rails.*
Cleveland	144,805	167,970	312,775	146,504
Cumberland	227,984	....	227,984	121,346
Lanc. and Chesh.	214,352	....	214,352	126,468
Sheffield	199,927	37,010	236,957	27,212
South Wales	414,959	....	414,959	114,306
Staff., Scotland, etc.	....	93,803	93,803	....
Total	1,202,027	298,783	1,500,810	535,836

The condition of the furnaces, production and stocks of pig-iron in the United Kingdom during 1892 are shown in the following table:

	Furnaces. In Blast.	Furnaces. Out of Blast	Pig Iron.* Production in tons.	Pig Iron.* Stocks, Dec. 31.	Stock in per cent of Output.
England	242	268	4,910,804	395,610	8.06
Scotland	77	38	977,213	443,646	45.4
Wales	28	73	728,873	32,839	10.2
Total	347	379	6,616,890	872,095	13.2

* Tons of 2240 pounds.

INDEX.

The Opinions of the World

on the

Statistical Numbers

of

The Engineering and Mining Journal.

JULES VIENNOT, Philadelphia, Pa., says: "I congratulate you upon your Annual Statistical Number as being a very remarkable one."

H. F. LYMAN, Cleveland, O., says: "Your January 2d edition is a wonderful production and I don't think you could be censured for feeling a little proud."

N. P. BURCH, Managing Director Quebrada Railway Land and Copper Co., Limited, London, England, says: "The statistics are very important and most valuable."

The *Literary Digest*, of New York, says: "It constitutes a perfect encyclopædia of both scientific and commercial knowledge of all the mineral resources of the continent."

WALTER C. HADLEY, Mining Engineer, Hadley, New Mexico, says: "Without a follower either in journalism or governmental bureaus, you have greatly surpassed all your former efforts."

The *Scientific American*, of New York, says: "These statistics have been compiled with the greatest possible care, neither labor nor expense being spared to secure accuracy in every particular."

The *Torch Lake Times*, Lake Linden, Mich., says: "This number of this excellent mining publication is brimfull of valuable statistics, and all parties interested in metals should have a copy."

The *Industrial World*, of Chicago, says: "Thanks for your encyclopædia of statistical facts and figures for 1891. A handsome notice will appear, in our issue of January 11th, of the 'treasures' it contains."

ROBERT F. HILL, House of Representatives, Washington, D.C., says: "Permit me to thank you for the able review of the mineral statistics of the United States. It was a magnificent exhibition of private enterprise."

JOHN C. HADDOCK of Messrs. Haddock, Shonk & Co., of New York, says: "I cheerfully acknowledge the receipt of your Annual Statistical Number. The mystery to me is how you do it and how you do it so well."

WILLIAM ALLEN SMITH, lecturer at Columbia College School of Mines, New York, says: "I tender my congratulations on your Statistical Number. It is away beyond even your own brilliant achievements of past years."

R. H. EDWARDS, Editor of the *Manufacturers' Record*, Baltimore, Md., says: "Permit me to congratulate you upon your magnificent special edition. It is the finest piece of work of the kind ever seen, and is a credit to American journalism."

J. B. RANDOL, San Francisco, Cal., the well-known authority on quicksilver, says: "Your great paper of January 2, 1892, in the language of the wide West is a "world beater," and I am proud of contributing to it even to the slight extent I did."

ROBERT W. HUNT, Ex-President of the American Society of Mechanical Engineers, says: "You certainly have reason to feel very proud of this Statistical Number, which represents an immense amount of work and will constitute a most valuable reference book."

The S. S. WHITE DENTAL MANUFACTURING COMPANY, Philadelphia, Pa., says: "We congratulate you upon the accuracy, inclusiveness and arrangement of the statistics, which are of world wide interest, and a creditable instance of the get-ahead-ness of the U. S. A."

THEODORE P. COLVILLE, of San Francisco, Cal., says: "Pray accept my congratulations on this wonderful compilation. It having just come to hand I have only been enabled to glance through it, but it seems as if it left little to be desired so far as mining statistics are concerned."

F. KOERNER, Wilkesbarre, Pa., says: "After the receipt of the Annual Statistical Number of the JOURNAL to-day, I cannot help expressing to you my amazement at the thing; I think it is safe to say that a like thing has never been done or even attempted. It cannot but be appreciated."

Professor DR. GEORGE LUNGE, of the Technisch-Chemisches Laboratorium, Zürich, Switzerland, says: "I have just received your Statistical Number, and I must congratulate you upon the wonderful energy displayed in compiling that record—a feat altogether unparalleled, to the best of my belief."

JOSEPH SELLWOOD, of Duluth, Minn., says: "I have just received a bound copy of your Statistical Number of THE ENGINEERING AND MINING JOURNAL, and fully appreciate it. It is full of valuable information. It must have been a wonderful amount of work to get those statistics together."

B. W. DOYLE, Secretary of the Pennsylvania Lead Company, Pittsburg, says: "In looking over your Annual Statistical Number we certainly find it very complete, not only as to the products in which we are interested, but also to all others appertaining to the production of minerals, metals, etc."

Major S. G. BROCK, Chief of the Bureau of Statistics, Washington, D. C., says: "Let me return my sincere thanks to you for your kindness in sending us an additional copy of your Statistical Number. It is a valuable statement for the year 1891, and we will probably have occasion to refer to it often."

Col. H. G. PROUT, Editor of the *Railroad Gazette*, New York, says: "Your Annual Statistical Number is certainly an extremely valuable and useful work, and it reflects great credit upon the organization of your office that you were able to collect such a mass of statistics and bring them out so promptly."

The *Export World and Prices Current*, New York, says: "The statistics of the world's mineral production have just been published by THE ENGINEERING AND MINING JOURNAL. They have been most conscientiously collected and carefully prepared and tabulated, and they are full of interesting suggestiveness."

ELFRIC DREW INGALL, Mining Engineer to the Geological Survey of Canada, says: "Let me express my great appreciation of the excellence of your Annual Statistical Number, and especially of the wonderful promptness with which you manage to issue it so shortly after the close of the year with which it deals."

A. HANAUER, President Hanauer Smelting Works, Salt Lake City, Utah, says: "I beg to acknowledge the receipt of the extra copy of your annual Statistical Number, for which accept my thanks. The work has been ably and conscientiously performed, and should be appreciated by all who are interested in the subjects covered."

WM. H. WILEY, Treasurer American Society of Mechanical Engineers, says: "As to your Statistical Number I want to congratulate you on the great enterprise shown in the collection of so many and such valuable facts. This paper is, itself, worth a year's subscription to the ENGINEERING AND MINING JOURNAL."

William L. Saunders, the well-known engineer of the Ingersoll-Sergeant Rock Drill Company, of New York, says: "This valuable compendium of mining news has long ago become a standard, and occupies a position in the library like that of an encyclopædia or a dictionary. It is more than either, because it is new and well up to date."

J. B. Haggin, of the Anaconda Mining Company, of Montana, says: "Many thanks for your kindness in sending me your Annual Statistical Number, which I have examined with great interest. I appreciate that the contents were a matter of great labor and trouble, and it is of inestimable value to the copper producers as well as the copper trade."

The *Tradesman* of Chattanoga, Tenn., in a personal letter, says: "Please accept the congratulations of the *Tradesman* on your splendid Annual Statistical Number. It is with no little degree of pleasure that we note this magnificent achievement in trade journalism, and as fellow-workers in the same line we desire to tender our cordial congratulations."

Alexander Montgomery, M.A., Inspector of Mines and Geological Surveyor, Launceston, Tasmania, says: "Allow me to take this opportunity of expressing my gratitude to the editors of The Engineering and Mining Journal for the most useful information contained in it. I have now taken the journal for about two years and find it indispensable."

Stuart W. Cramer, Assayer in charge of U. S. Assay Office, Charlotte, N. C., says: "Permit me to congratulate you upon the past year's work of the Journal, to which the Annual Statistical Number is a fitting climax. This number is an invaluable addition to any library, and is certainly the most enterprising specimen of journalism I have ever seen."

B. Hochschild, Treasurer of the American Metal Company, Limited, of New York City, says: "We have received the copy of the Annual Statistical Number for 1891, for which please accept our thanks. It is truly a remarkable and very interesting edition, and we must compliment you on the satisfactory completion of what must have been a tremendous task."

Messrs. Castner & Curran, of Philadelphia, agents of the Pocahontas Coal Company, say: "We were very much interested in your Annual Statistical Number, which contains a vast amount of very valuable statistics and general information. We have filed it away for future reference, as it is the best epitome of the trade that we have seen for a long while."

The Shendun (Virginia) *News*, says: "The issue of The Engineering and Mining Journal for January 2, 1892, contains 78 pages of statistical and other valuable information relative to the world's mineral production in 1891. This issue is the first of the 53d volume, and should be preserved for reference by every one interested in the mineral resources of the country."

James Douglas, President of the Copper Queen Consolidated Mining Company, of Arizona, says: "There can only be one opinion as to the value of your Annual Statistical Number to all engaged in the metal trade, and as to the immense enterprise, energy and skill you have shown in collecting such a body of statistics and publishing them almost the very day to which they apply."

Arthur Winslow, State Geologist, Jefferson City, Mo., says: "It seems to me there is only one opinion to be offered concerning your Annual Statistical Number, and that is that it is a valuable work of reference, and that it reflects great credit upon The Engineering and Mining Journal, either when the character of the contained material is considered, or when the surprising promptness with which you have issued these results is recognized."

M. Walton Brown, Secretary Federated Institution of Mining Engineers, Newcastle-upon-Tyne, England, says: "Allow me to offer you my congratulations on the recent issue of The Engineering and Mining Journal, containing the valuable statistics you have collected of the mineral production of the United States for the year just expired. The enterprise of such a laborious work leads one to believe that your paper is the leading one of the world."

The *Iron and Coal Trades Review*, of London, Eugland, says: "With its usual commendable enterprise and energy, The Engineering and Mining Journal presents its readers in its first number for the year with a full resumé of the mineral production of the United States in 1891. Our American contemporary annually imposes upon itself and its staff the arduous task of furnishing such information so promptly, and no praise is too great for such industry."

The *Daily Press,* Ishpeming, Mich., says: "The annual number of THE ENGINEERING AND MINING JOURNAL has reached the *Press.* To merely catalogue its leading articles would require a column. It contains twice as much matter as an average issue of the *Century* and is by all odds the most complete compendium of mining statistics ever issued in this country. It is invaluable and should be on the desk of every mining man in the upper peninsula."

M. C. IHLSENG, Professor of Mining, State School of Mines, Golden, Colo., says: "The Annual Statistical Number for 1892 arrived yesterday, and I cannot but address you with a letter with my humble commendation of your work, and must at the same time express my admiration for the elaborate work which was completed so promptly with the closing of the year. May you financially reap the reward which you certainly are enjoying technically."

Coal and Iron of London, England, says: "We have just received from the publishers of THE ENGINEERING AND MINING JOURNAL, New York, a copy of their issue of January 2d, containing the mineral statistics for 1891. This is the Annual Statistical Number of the JOURNAL, and is the work of many hands, the information being drawn from the most authoritative sources. The number is an exceedingly interesting one, and will be found very useful for reference."

W. D. LAWTON, Commissioner of Mineral Statistics of Michigan, says: "I think very highly of your Statistical Number. It is a volume of great value. This one I think is exceptionally good, though all your annual reviews are nearly indispensable. Every mining man of intelligence that I know of appreciates them, and keeps them for reference. It is a great undertaking to collate so much statistical matter, and you accomplish it admirably. I don't see how the mining world would get on without them now."

The *Critic,* Halifax, N. S., says: "The Annual Statistical Number of THE ENGINEERING AND MINING JOURNAL, containing the mineral statistics for 1891, is a most valuable compilation, and reflects great credit on the enterprise of its management and the painstaking work of its editorial staff. It is a concise summary of the year's work, and is of such great interest that we reproduce it in full, and shall in future issues draw largely from the rich mine of information furnished by the foremost mining journal in the world."

WILLIAM H. THURSTONE, Secretary of the Board of Trade, Buffalo, N. Y. says: "The varied statistics of the mineral products of the United States published in the January 2d number of THE ENGINEERING AND MINING JOURNAL have been accorded, by the unanimous opinion of all parties by whom the compilation has been seen in Buffalo, the greatest praise for its methods, work and results, accompanied with hearty good wishes for the future prosperity of the JOURNAL. This expression must be gratifying to all connected with the publication.

Captain WILLIAM EVANS, of the *Times,* Pittsburg, Pa., says: "The January number of your paper is the 'Boss' beyond all disputes, and is a credit to all concerned. The make-up is elegant. There is nothing complicated, nothing crowded, a place for everything and everything in its proper place. Writing an article or a table of figures is one thing; the arrangement of them in proper style is altogether another matter and requires a master hand. You have succeeded to perfection. There is nothing wanting; it is all there. Just think of it! Ninety-four pages of advertising. That shows that a good thing has been appreciated, and it is a compliment well deserved."

EDWARD D. PETERS, Jr., the well-known metallurgist and author of "American Methods of Copper Smelting," says: "As a stanch friend of THE ENGINEERING AND MINING JOURNAL I cannot forbear congratulating you on the extraordinary success of your attempt to show the exact statistical condition of the important metals. Such an idea has at times occurred to me; but I have dismissed it at once as being beyond the limits of possibility—especially in this country, where returns are not obligatory. I very much doubt if, with all their facilities, any European journal has ever succeeded in collating and publishing such a mass of valuable statistics in regard to the useful metals. Wishing you the success that such enterprise and ability deserves."

The *Engineering News*, of New York, in its issue of January 9th says: "Our esteemed and enterprising contemporary, THE ENGINEERING AND MINING JOURNAL, has done itself great honor for some years past by making its first issue of each year a special one devoted chiefly to the mineral statistics of the preceding year, which it has succeeded in compiling with remarkable promptness, and yet, as it is but just to add, with a very close approach to accuracy. This feature of the paper is now well understood by producers of metals and minerals, and we may reasonably expect to see each of these annual issues an improvement on the last. Certainly this present issue is a decided advance upon the last one, which we reviewed just a year ago, and then thought a very notable production."

R. A. F. PENROSE, Jr., of the Geological Survey of Arkansas, says: "Please allow me to add my congratulations to the many that you must receive on this annual Statistical Number. I consider it one of the most wonderful editorial feats ever performed in this country or abroad. That full and reliable statistics of the varied mining industries of the greatest mineral-producing country in the world can be compiled, published and issued two days after the year in question has closed, is a feat that would have been declared impossible by statisticians had you not proved its practicability. Yon have conferred a benefit of inestimable value on the thousands interested in the mineral developments of our country, and have made the JOURNAL indispensable to all interested in mining and manufacturing industries."

C. LE NEVE FOSTER, Professor of Mining, and one of the Queen's Inspectors of Mines, delivered at the Royal College of Science, London, on January 19th, 1891, a lecture on the Progress of the Art of Mining (statistical review of the mining industry in 1890), in which he says: "Before concluding my remarks upon the United States, I must express my admiration of their journalistic enterprise. I refer to the 'Annual Statistical Number' of the ENGINEERING AND MINING JOURNAL, of New York, dated January 3d, which reached me two days ago, giving very complete mineral statistics of their great continent. Knowing from actual experience the labor entailed in collecting and preparing such statistics, I can form some estimate of the difficulties that had to be overcome; and when a private firm accomplishes a task which *no government in Europe has ever thought possible*, viz., the publication of its mineral statistics within three days after the completion of a year, the meed of praise should be full and unstinted."

Dr. DAVID T. DAY, Chief of Division, Department of the Interior, United States Geological Survey, Division of Mining Statistics and Technology, Washington, D. C., says: "It gives me great pleasure to testify to the valuable service which the ENGINEERING AND MINING JOURNAL has rendered in the development of the mining industries of the United States. The rapid advancement of these industries in our country has been primarily due, of course, to the stimulus of finding valuable ore-beds under particularly inviting conditions; but the comparatively stable condition of the industry and the enlightened use of improved mining machinery show that the influence of good journalism has been appreciated; and certainly no journal has kept as enterprising, independent, and reliable watch over the interests of the mining community as the ENGINEERING AND MINING JOURNAL under Mr. Richard P. Rothwell. There is no other publication of any kind of such good standing and of so much influence among our engineers and in financial circles."

The *Daily Times*, Marquette, Mich., says: "The Annual Statistical Number of THE ENGINEERING AND MINING JOURNAL has come to hand, and is a grander monument than ever to the enterprise and industry of the publishers of that journal, the foremost mining journal of the world. Its statistics are as reliable and nearly as complete as government statistics. The figures all come from official sources and are presented in such a manner that their lesson is apparent to the most common reader. The labor involved in compiling the mineral statistics of a continent, to say nothing of the elaborate reports from all quarters on the operations, developments and prospects of mineral properties, all brought down to the very close of 1891, is a task only THE ENGINEERING AND MINING JOURNAL can undertake, for it alone has the facilities at its command. All thinking men and all who are financially or otherwise interested in minerals will preserve this number, and if thereto they add a year's subscription to the journal they will accumulate a library of valuable information that cannot be had elsewhere."

☞ **Many hundred of opinions could be added to this list if space would permit.**

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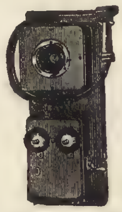

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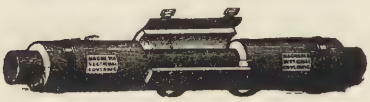

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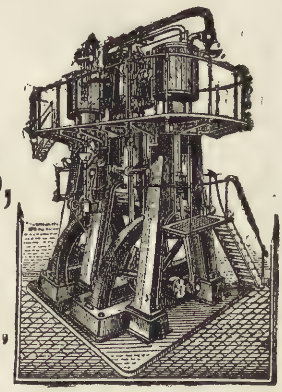

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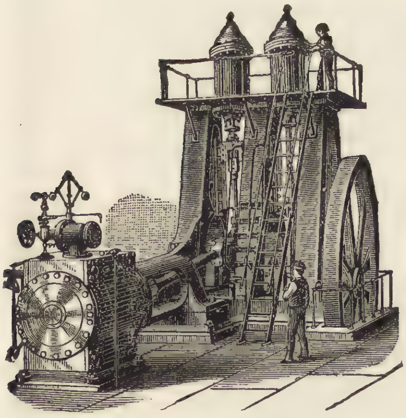

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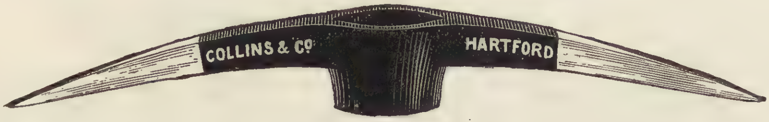

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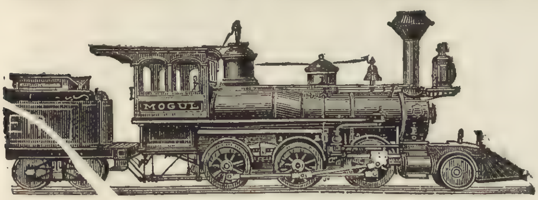

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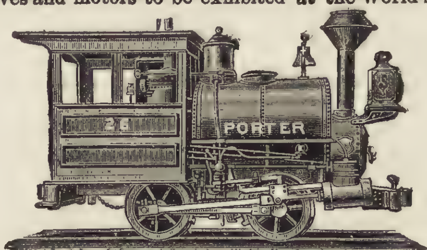

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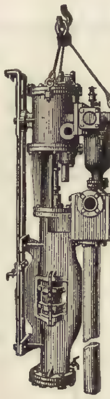

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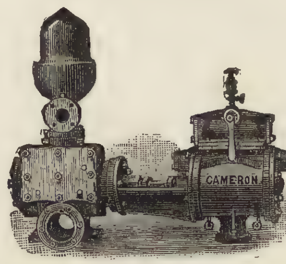

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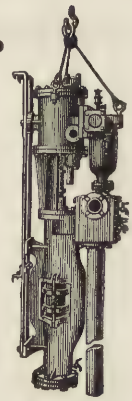

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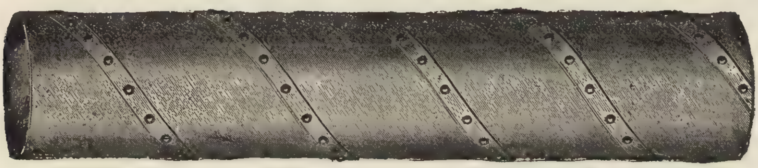

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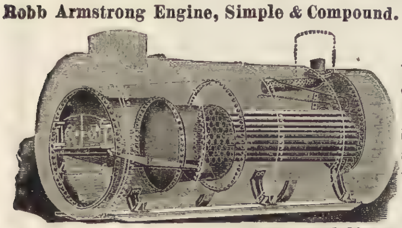

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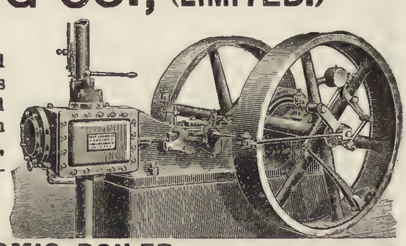

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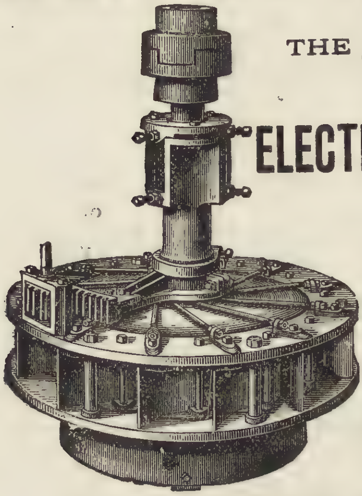

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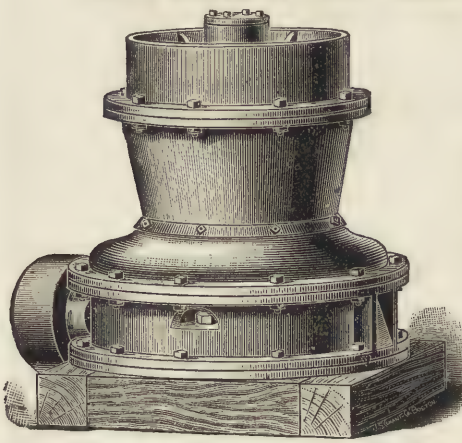

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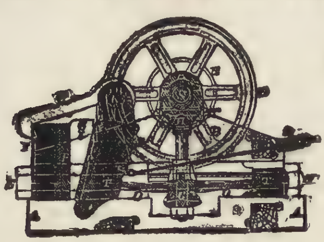

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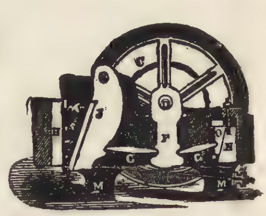

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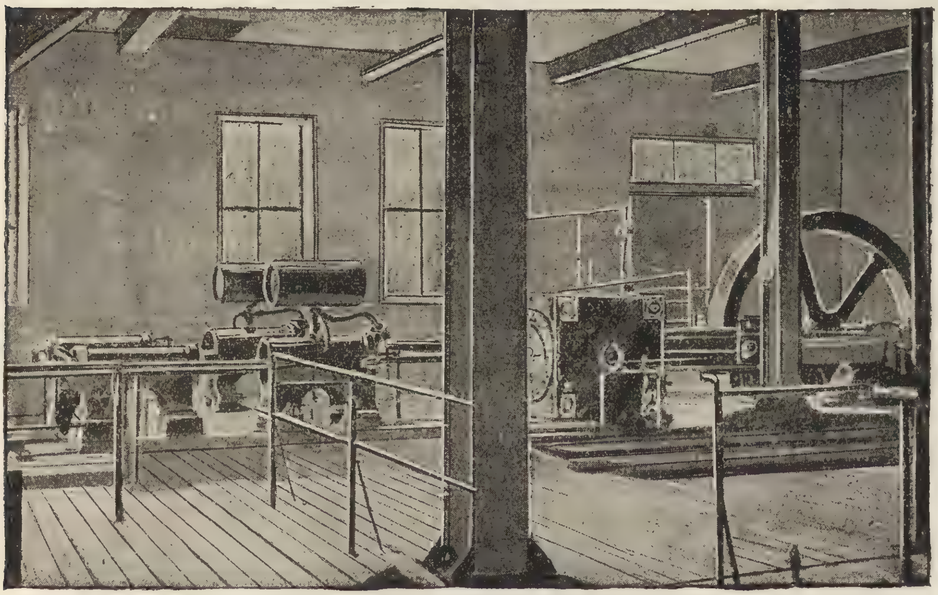

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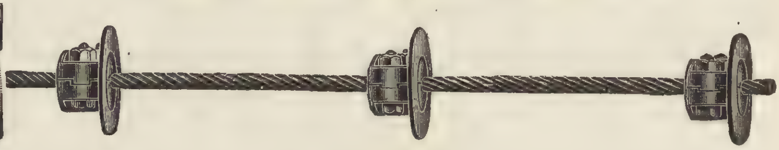

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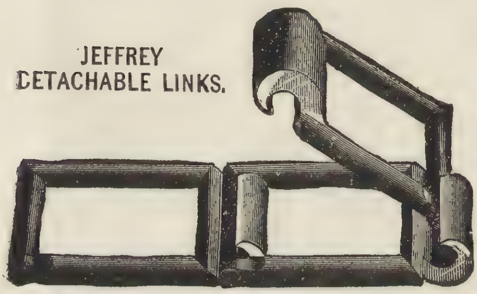

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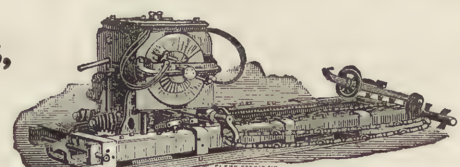

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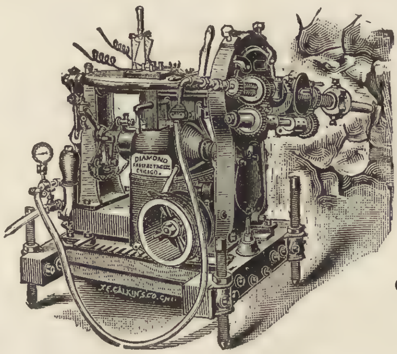

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